

Manufacturing Systems Demonstration

PRON: R302C208R3

Focus: HOPE Center for Advanced Technology



Contract No: W56HZV-05-C0721

Start: 20 September 2010

Completion: 20 January 2012

WD-FH-0004 Task 3.2

Manufacture and Preparation of Test Specimens for Johnson-Cook Material Characterization

Report Date: 10 January 2012

(Text and format edited Jan 2013)

Contract Officer Tech. Representative: M. M. McDonnell (586) 282-7999
U.S. Army TARDEC, Warren, MI

Project Engineer: R. E. Miller (313) 494-4716
FH – CAT, Detroit, MI

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| Report Documentation Page | | | Form Approved OMB No. 0704-0188 | | | | | |
|---|---|---|--|---|-------------------------------------|---|----------------------------------|---------------------------------|
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| 1. REPORT DATE 10 JAN 2013 | 2. REPORT TYPE Technical Report | 3. DATES COVERED 20-09-2010 to 20-01-2012 | | | | | | |
| 4. TITLE AND SUBTITLE Manufacture and Preparation of Test Specimens for Johnson-Cook Material Characterization | | | 5a. CONTRACT NUMBER W56HZV-05-C0721 | 5b. GRANT NUMBER | | | | |
| | | | 5c. PROGRAM ELEMENT NUMBER | | | | | |
| 6. AUTHOR(S) R Miller | | | 5d. PROJECT NUMBER | 5e. TASK NUMBER | | | | |
| | | | 5f. WORK UNIT NUMBER | | | | | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Focus: HOPE Center for Advanced Technology, 1355 Oakman Boulevard, Detroit, Mi, 48238 | | | 8. PERFORMING ORGANIZATION REPORT NUMBER WD-FH-0004 Task 3.2 | | | | | |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army TARDEC, 6501 East Eleven Mile Rd, Warren, Mi, 48397-5000 | | | 10. SPONSOR/MONITOR'S ACRONYM(S) TARDEC | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) #23657 | | | | |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited | | | | | | | | |
| 13. SUPPLEMENTARY NOTES | | | | | | | | |
| 14. ABSTRACT <p>As a revision to Contract #W56HZV-05-0721 (WD-FH-0004), this task was added to the current project for the purpose of performing material characterizations and developing Johnson-Cook (J-C) strength and damage constants of friction stir welded (FSW) ballistic joints. These material constants will be used by the government for ballistic blast and other types of modeling and simulation, and will be included in the Elastic Plastic Impact Code (EPIC) library. This report describes the welding and machining processes used to manufacture the material test specimens used for the J-C material characterization tests and provides the results of metallurgical analysis for the FSW joint of each selected armor material.</p> | | | | | | | | |
| 15. SUBJECT TERMS | | | | | | | | |
| 16. SECURITY CLASSIFICATION OF: <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%; padding: 2px;">a. REPORT unclassified</td> <td style="width: 33%; padding: 2px;">b. ABSTRACT unclassified</td> <td style="width: 33%; padding: 2px;">c. THIS PAGE unclassified</td> </tr> </table> | | | a. REPORT unclassified | b. ABSTRACT unclassified | c. THIS PAGE unclassified | 17. LIMITATION OF ABSTRACT Public Release | 18. NUMBER OF PAGES 98 | 19a. NAME OF RESPONSIBLE PERSON |
| a. REPORT unclassified | b. ABSTRACT unclassified | c. THIS PAGE unclassified | | | | | | |

TABLE OF CONTENTS

| | | |
|-----|---|----|
| 1.0 | INTRODUCTION | 2 |
| 2.0 | WELD COUPON MANUFACTURING | 3 |
| 2.1 | Material | 3 |
| 2.2 | Coupon Production | 3 |
| 3.0 | WELD JOINT METALLURGICAL ANALYSIS | 7 |
| 3.1 | Sample Preparation | 7 |
| 3.2 | Microstructural Analysis | 7 |
| 3.3 | Microhardness..... | 10 |
| 3.4 | Electron Backscatter Diffraction | 12 |
| 3.5 | Tensile Strength..... | 15 |
| 3.5 | J-C Test Specimen Location | 17 |
| 4.0 | FINAL SPECIMEN MACHINING | 18 |

Appendix A – FSW Process Parameter Development Tables

Appendix B – Test Specimen Prints

Appendix C – FH-CAT Machining Process Details

1.0 INTRODUCTION

As a revision to Contract #W56HZV-05-0721 (WD-FH-0004), this task was added to the current project for the purpose of performing material characterizations and developing Johnson-Cook (J-C) strength and damage constants of friction stir welded (FSW) ballistic joints. These material constants will be used by the government for ballistic, blast and other types of modeling and simulation, and will be included in the Elastic Plastic Impact Code (EPIC) library. This report describes the welding and machining processes used to manufacture the material test specimens used for the J-C material characterization tests and provides the results of metallurgical analysis for the FSW joint of each selected armor material.

At the onset of this project, U.S. Army TARDEC personnel identified six armor materials (See Table 1-1) which were either currently in use or under consideration for future use for ballistic structures and had not undergone FSW joint material strength characterization. Due to budgetary limitations, only three of these materials were selected for J-C analysis: 6061, 5083, and 2139 aluminum alloys. TARDEC wanted high-hardness steel armor to be one of the chosen materials however preliminary FSW tool trials using a tungsten-rhenium tool to weld ½-inch thick plate of this material indicated that excessive tool wear would prohibit its inclusion in this study. Development of FSW weld joints of high-hardness steel armor are continuing at FH-CAT with the goal of including this material in a future J-C material characterization study.

TABLE 1-1: Ballistic Armor Materials

-
- 1. 6061-T6511 aluminum alloy, Class 1, MIL-DTL-32262
 - 2. Steel - high-hardness, MIL-DTL-46100E
 - 3. 5083-H131 aluminum alloy, Class 1, MIL-DTL-46027K
 - 4. 2139-T8 aluminum alloy, Class 1, MIL-DTL-32341
 - 5. 2195-T64 aluminum alloy, Class 2, MIL-DTL-32341
 - 6. Steel – homogeneous, Class 1 or 2, MIL-DTL-12560J

2.0 WELD COUPON MANUFACTURING

2.1 Material

The 6061 aluminum armor used for this project was manufactured by Kaiser Aluminum (Fairfield, IL) and was delivered as 1-in. x 2-in. x 12-ft. bars (Lot #Z00222015). The full-length bars were then cut into 8-in. lengths¹ using a band saw with cooling fluid.

The 2139 aluminum armor used for this project was manufactured by Alcan Rolled Products (Ravenswood, WV). Due to the limited availability of this experimental armor, it was delivered as three large plates: one 1-in. x 24-in. x 47.5-in. (Lot #820081) and two 1-in. x 48-in. x 48 in. (Lot # 820091). The plates were cut into 2-in. wide bars using a water-jet machine and these bars were then cut into 8-in. lengths using a band saw with cooling fluid. One side of each bar was milled to remove the surface finish left by the water-jet cutting process.

The 5083 aluminum armor used for this project was also manufactured by Alcan and originally delivered to Sunshine Metals (Glenpool, OK) as a 1 1/8-in. x 20-in. x 170-in. plate (Lot #125831). At Sunshine, the plate was then milled to 1.0-in. thick and then sawed into the 12-in. x 156-in. plate that was subsequently delivered to FH-CAT². The plate was then cut into 2-in. x 8-in. segments using a band saw with cooling fluid. One side of each bar was milled to remove the saw marks.

2.2 Coupon Production

The weld coupons (Figure 2-1) were all manufactured on the same FH-CAT FSW machine, a Transformation Technologies, Inc. (Elkhart, IN) Model GG1 (Figure 2-2), in single batches for each material. For all three materials, an FSW tool made of H13 tool steel with a scrolled pin and shoulder (See Figure 2-3) was used however the different heat requirements of the materials required that different tool shoulder diameters be used; 50.8-mm for 6061 and 40-mm for 5083 and 2139. The 6061 coupons were

¹At the beginning of this expedited project an FSW coupon fixture and machine program that was currently in use at FH-CAT at that time was used for coupon manufacturing.

² This 12-in. wide plate was originally ordered as material for ballistic target weldments.

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completed on July 11, 2011, the 5083 coupons on August 2, 2011, and the 2139 coupons on November 9, 2011.



Figure 2-1: 6061 FSW Coupon



Figure 2-2: Friction Stir Weld Machine

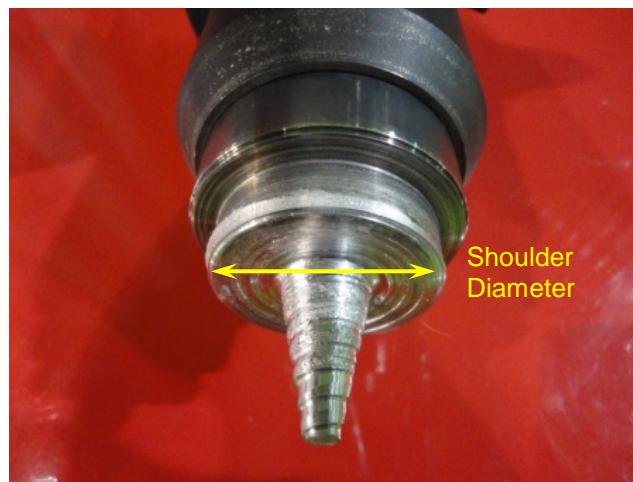


Figure 2-3: FSW Tool (40-mm dia. shown)

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Other than the material-specific welding parameters shown in Table 2-1, the manufacturing of each coupon followed the following process:

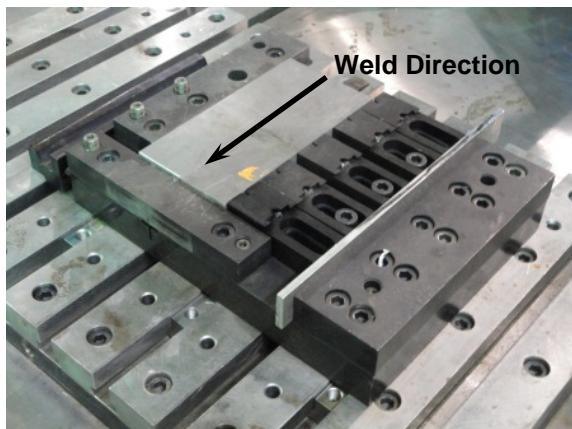
1. Clean two material bars with ethyl alcohol and a disposable towel.
2. Blow debris from the fixture using a compressed air nozzle.
3. Place the bars into the fixture (See Figure 2-4), with the square/milled sides at the joint, and tighten the fixture clamps with a hex head torque wrench (25 ft-lbs).
4. Inspect the material installation to confirm proper positioning and fit.
5. Using machine manual mode, lower the spindle so that the FSW tool tip is near the top of the material bars. The exact point of where the tip contacts the material is then found using the manual mode micro adjustment knob. Recalibrate the Z-axis positioning to account for fixture height variations caused by heat variations.
6. Initiate the CNC welding program via the machine's operator interface panel.
7. Visually monitor the entire welding cycle.
8. Upon completion of the automated welding cycle, the welded coupon remains in the fixture for 1-2 minutes to allow cooling.
9. Visually inspect the quality of the weld.
10. After the in-fixture cooling period, release the clamps and transfer the coupon to the machine's bed plate to allow it to cool to room temperature.
11. During this cooling step, mark the coupon with a sequential number using a paint pen.
12. Allow the empty fixture to cool before installing the next set of material bars.
(The cooling period was 10 minutes minimum for the 6061 and 5083 materials. Due to high spindle torque during welding of 2139 coupons, the fixture and machine were cooled for a minimum of 30 minutes.)

On several occasions for all material batches, the time span between individual coupon welding was several hours to several days because of personnel and shop work schedules.

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Table 2-1: FSW Coupon Process Parameters

| | <i>Tool Shoulder Dia. (mm)</i> | <i>Rotation (RPM)</i> | <i>Traverse Speed (mm/min)</i> | <i>Axial Force (kN)</i> | <i>Tilt Angle (deg.)</i> | <i>Tool Coolant</i> |
|------|--------------------------------|-----------------------|--------------------------------|-------------------------|--------------------------|---------------------|
| 6061 | 50.8 | 450 | 150 | 45 | 2 | no |
| 5083 | 40.0 | 300 | 25 | 33 | 3 | yes |
| 2139 | 40.0 | 250 | 40 | 43 | 3 | yes |

**Figure 2-4: Coupon Weld Fixture**

As preparation for X-ray inspection of the welds, each coupon was machined to remove the inherent FSW flaws. Both ends of the coupons were removed using a laboratory precision wet saw to remove the weld starts and exit holes and to set the final coupon lengths of 4.5-in. The top surface of each coupon was then milled to remove weld flash.

Each material batch of coupons was then X-ray inspected at Magna Chek Inc. (Madison Heights, MI). None of the coupons exhibited any internal flaws.

3.0 WELD JOINT METALLURGICAL ANALYSIS

3.1 Sample Preparation

After the material-specific FSW process parameters were optimized (See Appendix A for development process parameters.), a set of coupons was segmented using a laboratory wet saw to provide transverse weld joint samples for hardness evaluation, micrographs, scanning electron microscopy (SEM), electron backscatter diffraction (EBSD), and tensile strength analysis. As required, samples were mounted, polished, and/or chemical etched (Keller's reagent). The transverse tensile test specimens (ASTM E8 – flat, sub-size) were machined and tested at FH-CAT (See Figure 3-1).

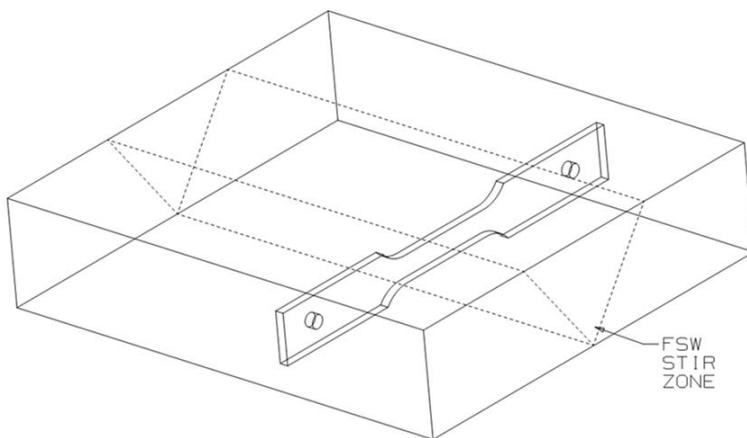


Figure 3-1: FH-CAT Tensile Test Specimen Location

3.2 Microstructural Analysis

Microstructural analysis was conducted using a Nikon Eclipse LV150 optical microscope and a Zeiss EVO MA10 SEM. Images were obtained from the optical microscope using a calibrated digital camera, and Scenaris software. Optical microscope images were captured at 500x magnification and SEM images were captured at 500x and 1000x magnifications. Figures 3-2, 3-3 and 3-4 show the microscopic results for Al 6061, Al 5083, and Al 2139 respectively.

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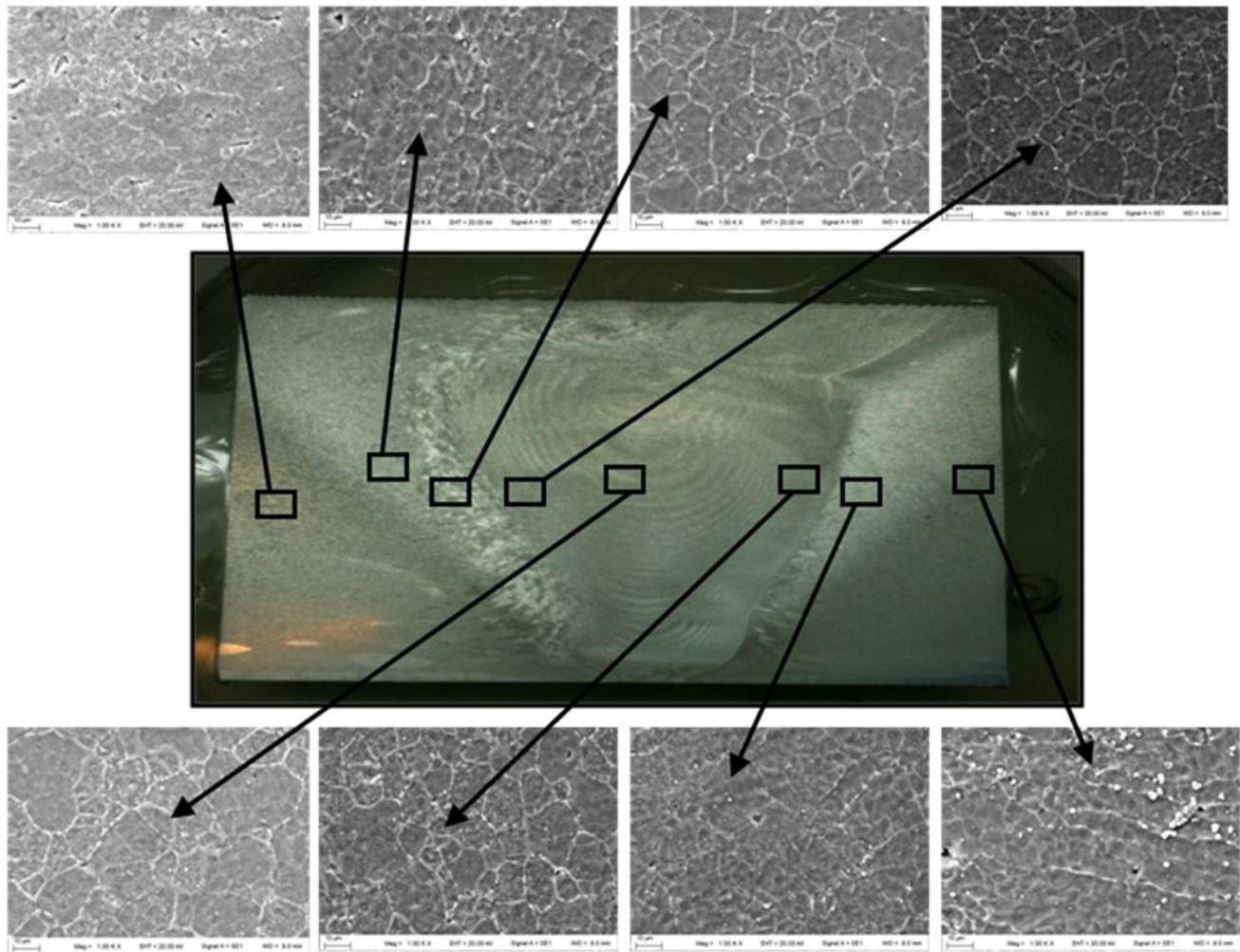


Figure 3-2: Microscopic Views of 6061 FSW Joint

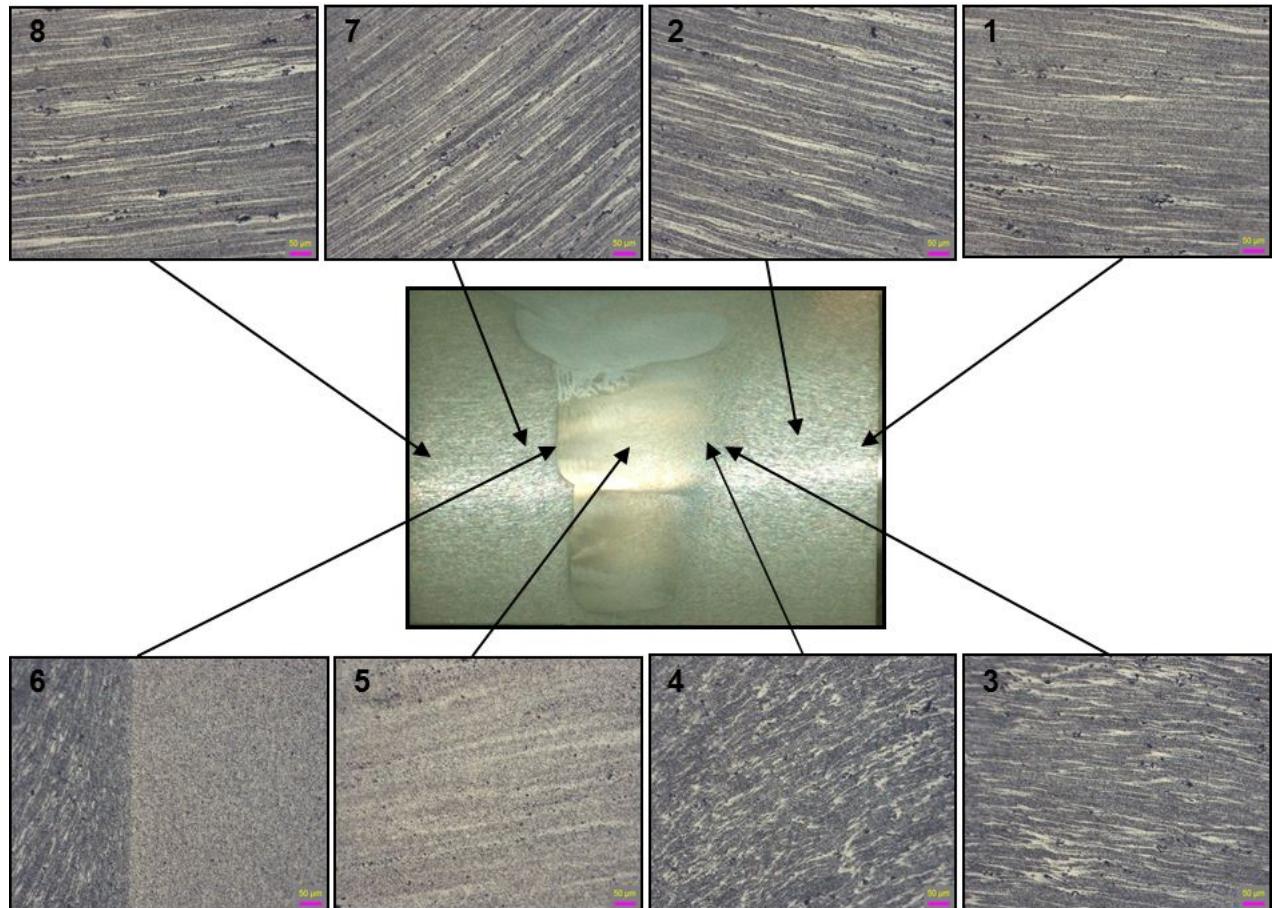


Figure 3-3: Microscopic Views of 5083 FSW Joint.

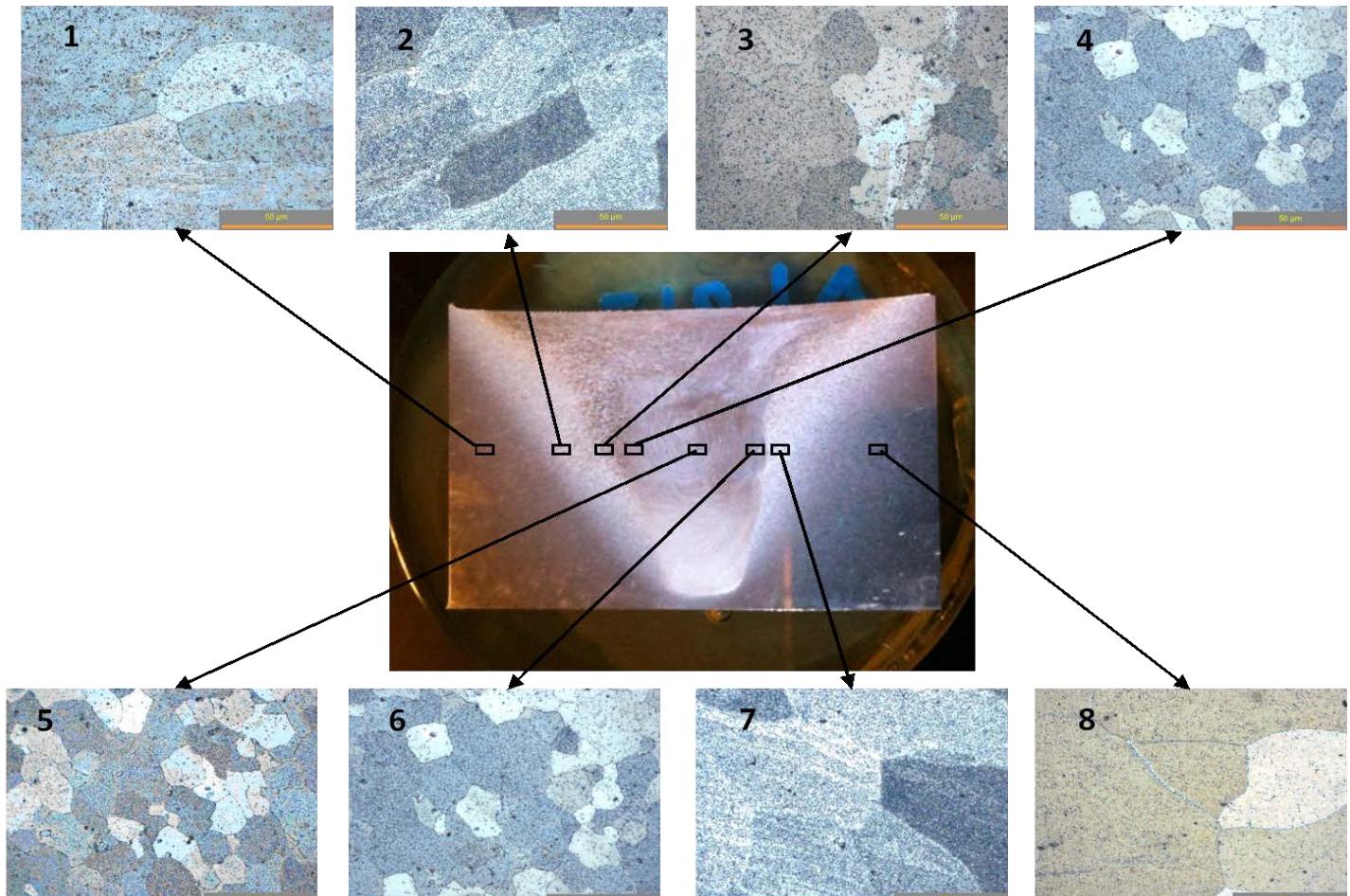


Figure 3-4: Microscopic Views of 2139 FSW Joint.

3.3 Microhardness

Microhardness charts were created using a Leco LM100AT hardness tester. Figure 3-5 compares the microhardness charts for the 6061, 5083, and 2139 FSW weld joints.

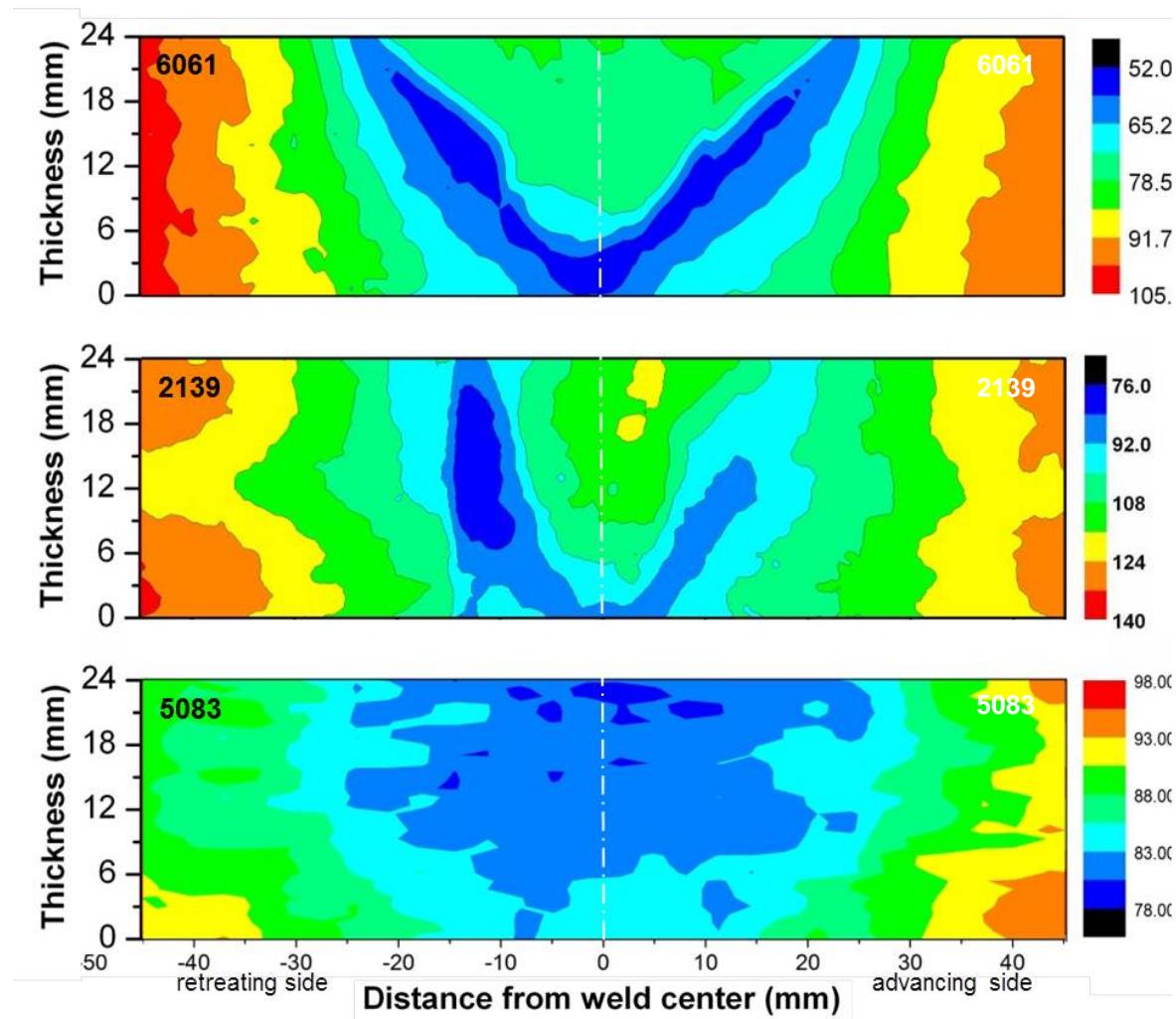


Figure 3-5 : FSW Joint Micro-Hardness (HV)

3.4 Electron Backscatter Diffraction

Further definition of the metallurgic grain structure across the weld joint was conducted using EBSD. Prepared FSW joint samples were analyzed with a Hikari/EDAX backscatter detection system mounted to a Zeiss EVO MA10 SEM. Figures 3-6, 3-7, and 3-8 show the EBSD results.

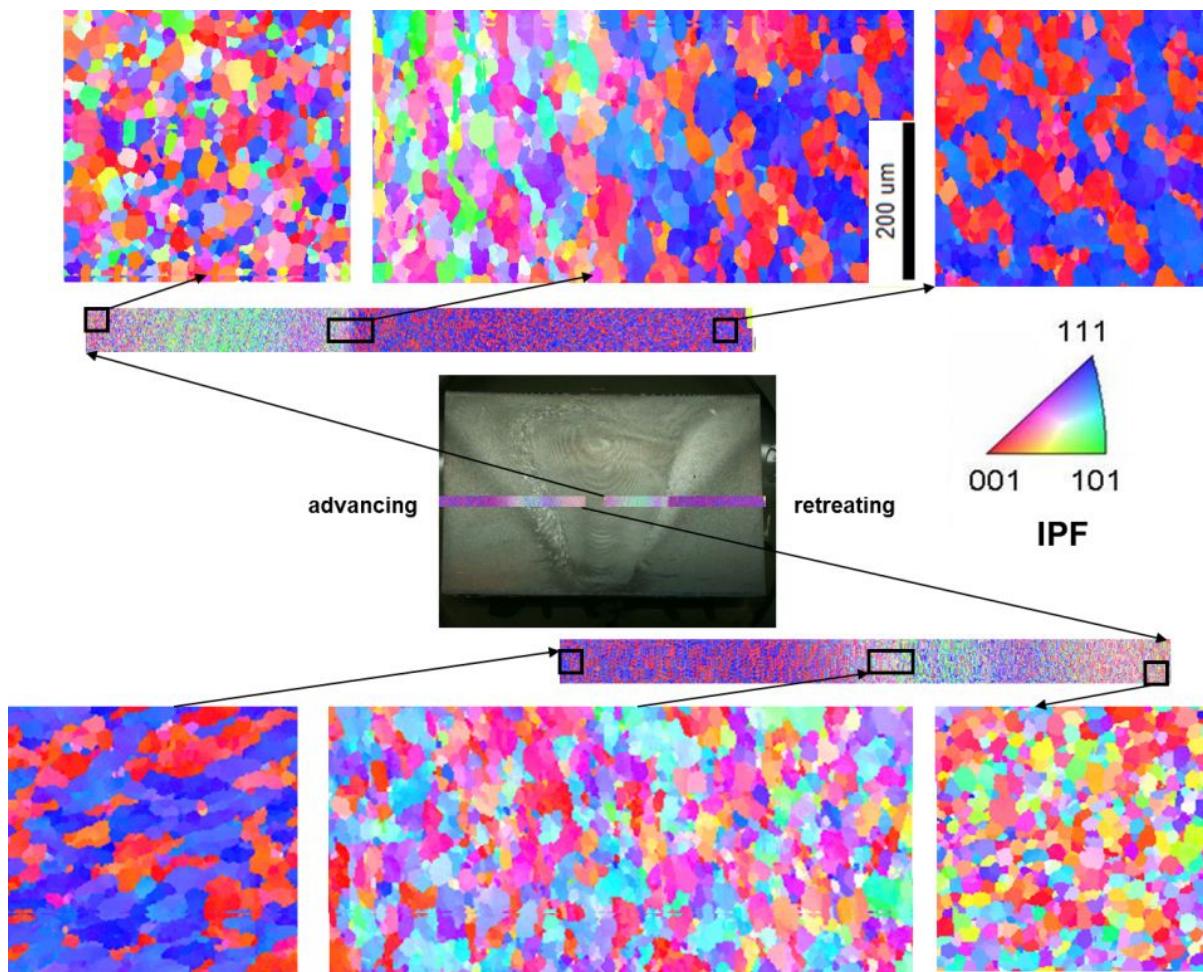


Figure 3-6: EBSD of 6061 FSW Joint

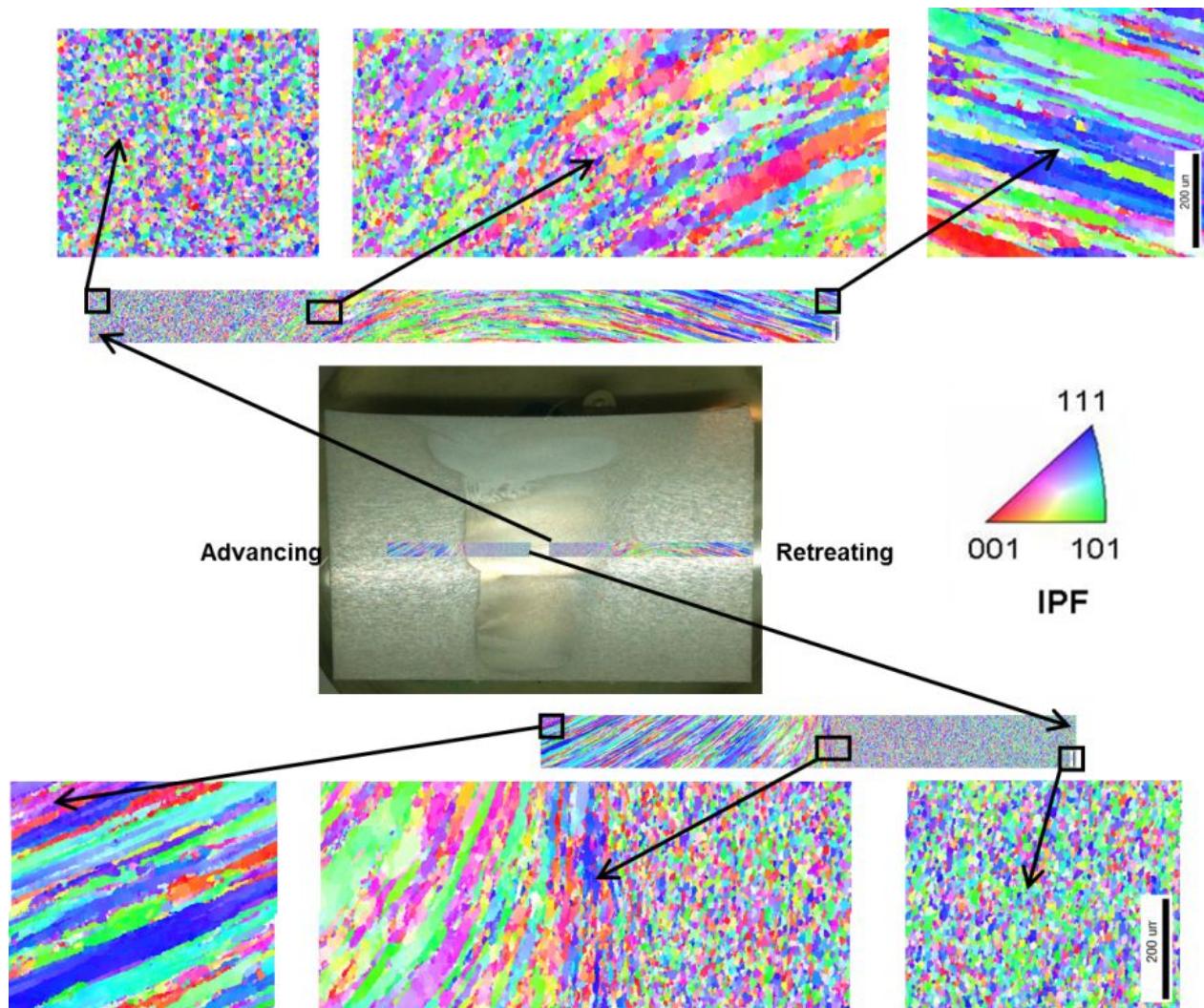


Figure 3-7: EBSD of 5083 FSW Joint

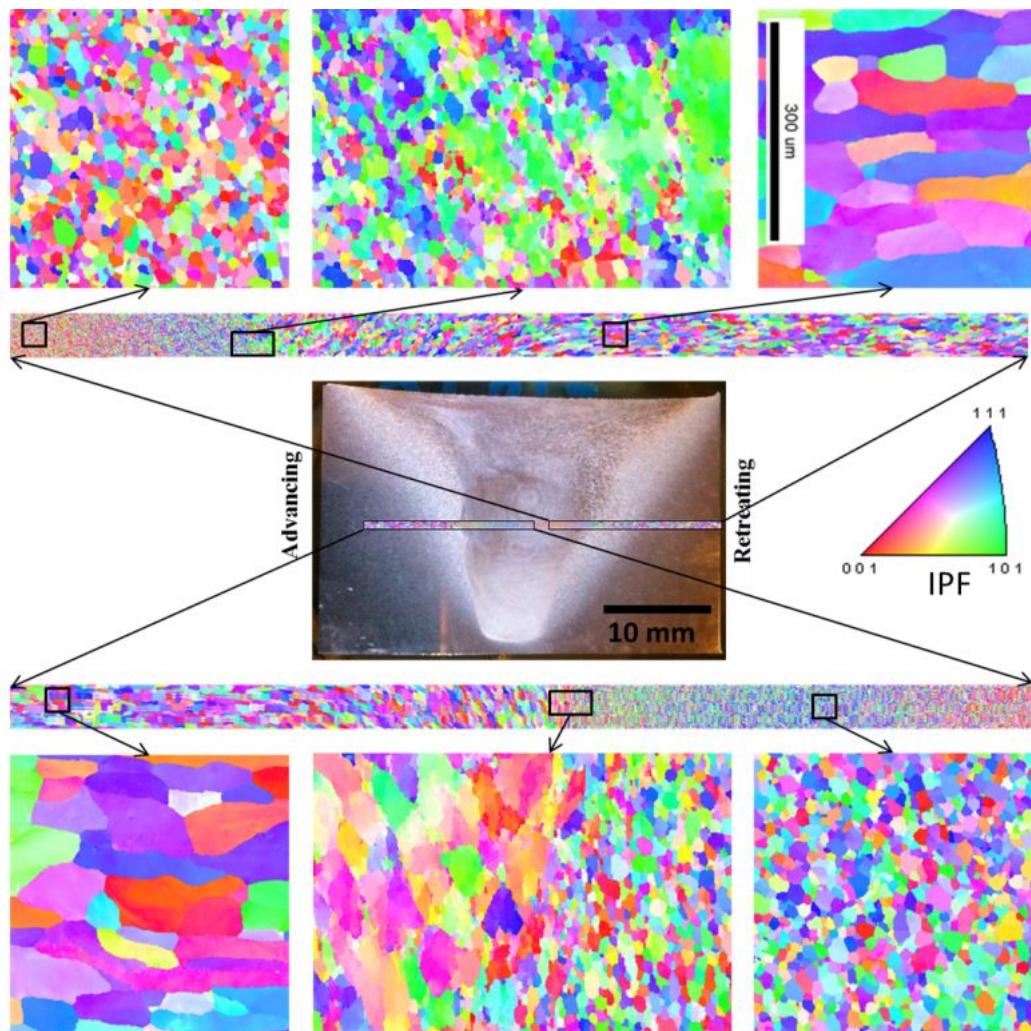


Figure 3-8: EBSD of 2139 FSW Joint

3.5 Tensile Strength

Tensile tests were conducted using an Instron Model 5982 universal testing machine with a strain rate of 1 mm/min. The force was measured using a 100 kN load cell, and elongation was measured using a 1-in. length extensometer. Table 3-1 compares the strength test results for all three FSW materials with their respective base materials. Figures 3-9, 3-10, and 3-11 show the stress vs. strain relationships of the FSW joints.

Table 3-1 : Tensile Test Results

| | <i>Yield Strength (MPa)</i> | <i>Ultimate Yield (MPa)</i> | <i>% Elongation</i> |
|------------------|-----------------------------|-----------------------------|---------------------|
| 6061 FSW | 194 | 270 | 7.06% |
| 6061 Base | 507 | 576 | 12% |
| % Change | -61.7% | -53.1% | -41.2% |
| 5083 FSW | 229 | 394 | 18.4% |
| 5083 Base | 333 | 442 | 19% |
| % Change | -31.2% | -10.9% | -3.2% |
| 2139 FSW | 235 | 405 | 14.9% |
| 2139 Base | 475 | 500 | 13.1% |
| % Change | -50.5% | -19.0% | 13.7% |

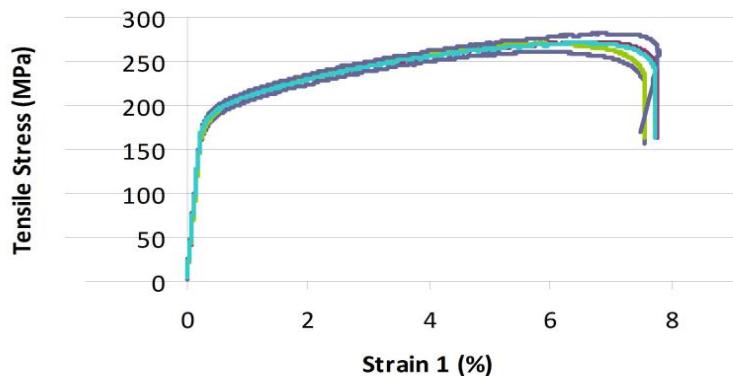


Figure 3-9: 6061 FSW Stress vs. Strain

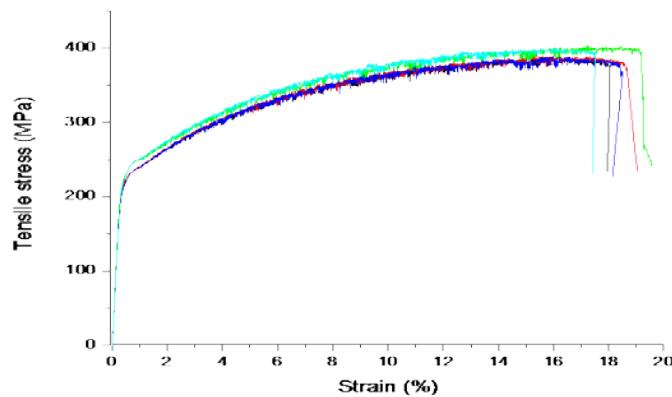


Figure 3-10: 5083 FSW Stress vs. Strain

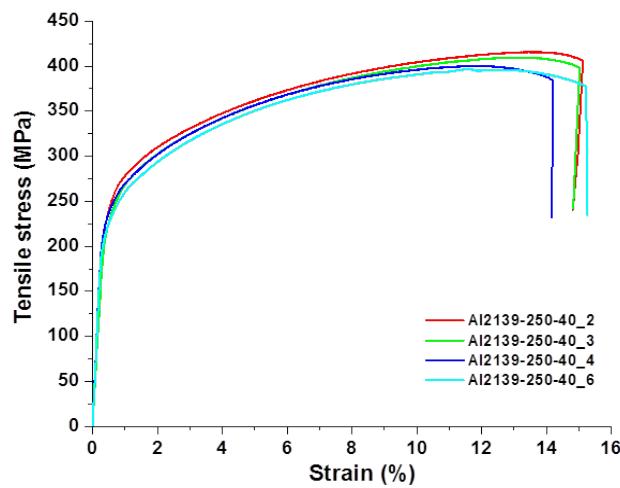


Figure 3-11: 2139 FSW Stress vs. Strain

3.5 J-C Test Specimen Location

SWRI selected the centerline positions of the final specimens using the coupon transverse micro-hardness chart (See Figure 3-12) and macro-etch sample for each material. While the weakest part of an FSW joint is typically the thermo-mechanically affected zone (TMAZ) where the softest material is found, commonality with a previous FSW joint characterization study³ was the driving factor for the positions selected for this project. For only the 2139 FSW zone material, the horizontal centerline of the specimen location was slightly lower (1.3-mm) than all other locations to avoid a small area of relatively harder material in the upper, advancing side of the FSW zone.

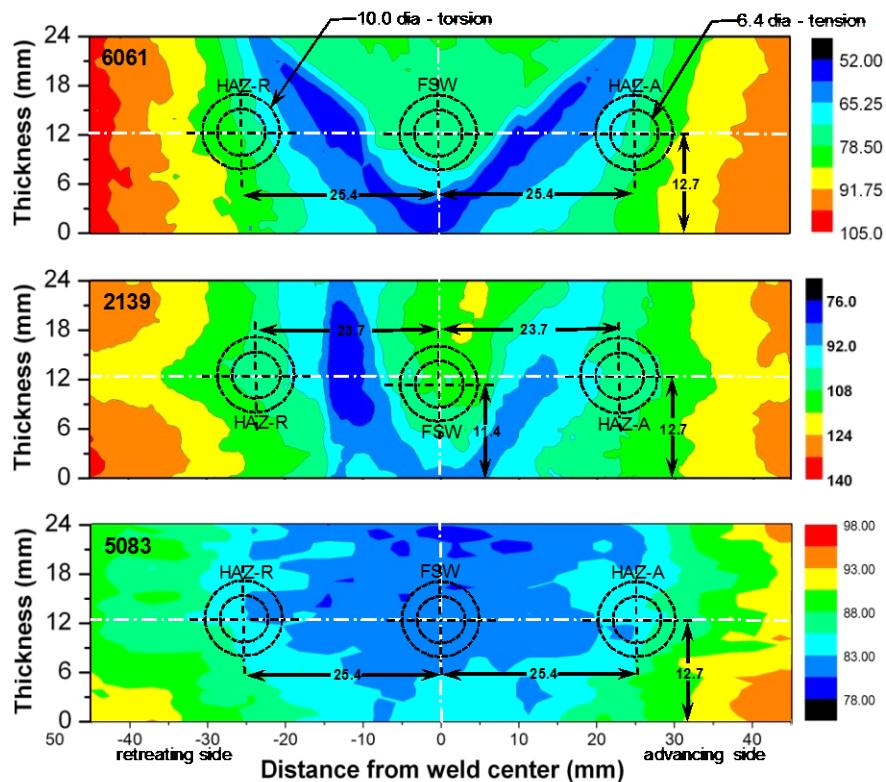


Figure 3-12: Specimen Locations

³ TARDEC Report 18.12544/026, *Mechanical Characterization of Friction Stir Welded Aluminum 5059-H131 (Weld and Heat Affected Zone) for Determination of Johnson-Cook Constitutive Constants*, Sep 2010, Southwest Research Institute, San Antonio, TX

4.0 FINAL SPECIMEN MACHINING

After returning from X-ray inspection, three specimen bars were longitudinally extracted from each FSW coupon; FSW zone, HAZ advancing side, and HAZ retreating side (See Figure 4-1).

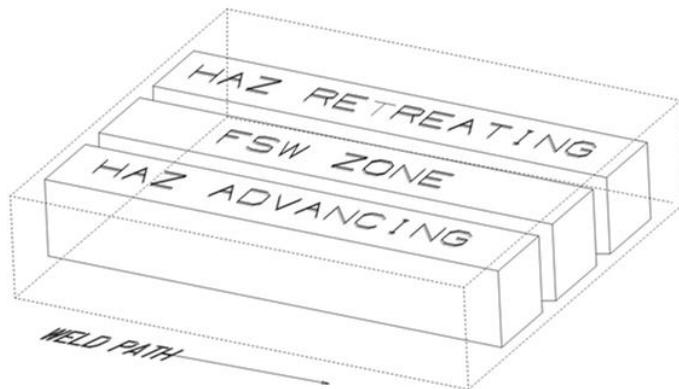


Figure 4-1: Specimen Bar Coupon Locations

To duplicate previous J-C strength and damage studies of armor material conducted at SWRI, several different specimen configurations were required from each of the coupon specimen positions (See Table 4-1). See Appendix B for the specimen design prints and Appendix C for FH-CAT machining process descriptions.

For all of the specimen bars of the 6061 and 5083 material sets, one end was machined using a Cincinnati 630XT CNC machining center to a diameter of 0.75-in. (0.80-in. for B and E Notch Tension specimen bars) to aid subsequent processes. One end of $\frac{3}{4}$ -13 UNC-2A threads for the B and E Notch Tension specimen bars were also machined at this operation. Throughout the FH-CAT manufacturing process, material coupons, specimen bars, and specimens were segregated into separate bins, bags, and/or laser marked between process steps. Each specimen was individually bagged for shipping to SWRI.

6061 and 5083 base material .250 Tension specimens were initially produced as a machining process trial and then provided to SWRI for inspection and approval. With their approval, “production” manufacturing of the FSW test specimens began.

Table 4-1: J-C Test Specimens

| Material Location | Test Type | Specimen Type | SWRI Dwg. No. | Qty |
|-------------------|---------------------|--------------------------|--|-----|
| FSW ZONE | Quasistatic Tension | Threaded cylind. tensile | 18-01147-510-5A | 8 |
| | B-Notched Tension | Threaded cylind. tensile | 18-01147-510-3 | 4 |
| | E-Notched Tension | Threaded cylind. tensile | 18-01147-510-4 | 4 |
| | SHPB Tension | Threaded cylind. tensile | "SHPB Tensile" | 8 |
| | SHPB Compression | Cylinder L/D=2 | 18-01147-510-6 | 16 |
| | Taylor Anvil | Cylinder L/D = 5 | "T.A.I.T Specimen" 10-11-2005 | 10 |
| | Torsion | Hollow, Hex head | "Torsion Specimen Subsize" 07-21-2005 | 8 |
| HAZ ADVANCE | Quasistatic Tension | Threaded cylind. tensile | 18-01147-510-5A | 4 |
| | Taylor Anvil | Cylinder L/D = 5 | "T.A.I.T Specimen" 10-11-2005 | 10 |
| HAZ RETREAT | Quasistatic Tension | Threaded cylind. tensile | 18-01147-510-5A | 4 |
| | Taylor Anvil | Cylinder L/D = 5 | "T.A.I.T Specimen" 10-11-2005 | 10 |
| BASE | Quasistatic Tension | Threaded cylind. tensile | 18-01147-510-5A | 8 |

The Quasistatic Tension, SHPB Tension, SHPB Compression, and Taylor Anvil Impact Test specimens of the 6061 and 5083 materials were machined at FH-CAT. Due to machine resource limitations at FH-CAT, the machining of the 6061 and 5083 B-Notch Tension, E-Notch Tension, and Sub-size Torsion specimens and all of the 2139 specimens was done by the SWRI machine shop using FSW material blanks provided by FH-CAT.

The FH-CAT Quasistatic and SHPB Tension specimens were turned to final shape and threaded using a Mazak 100-III3 CNC machining center yielding one specimen per material blank. These specimens were then manually polished using a bench grinder with a 6-in. dia. sewn cotton buffing wheel. For the final operation, each tension

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specimen was inserted into a ½-in. inside diameter plastic tube to protect the surface finish and then cut to final length using the Mazak 100. Figure 4-2 depicts the complete manufacturing process, material bars thru final machining, for the tension specimens.

The Taylor Anvil Impact Test (TAIT) specimen blanks were turned to 0.625-in. diameter using the Mazak 100 and subsequently turned to final diameter and rough length using a Hardinge Conquest T42 CNC lathe. This process yielded three specimens per material blank. The TAIT specimens were then milled to final length using a Cincinnati VMC500 CNC machining center.

The SHPB Compression specimens were turned to final diameter and rough length (four per blank) using the Hardinge CNC lathe and were then milled to final length using the Cincinnati VMC500.

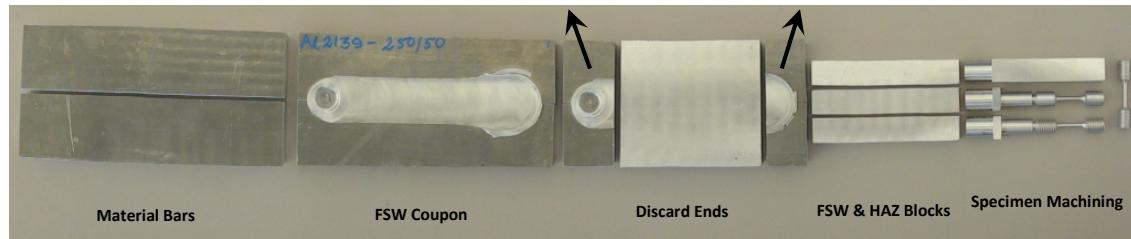


Figure 4-2: Specimen Manufacturing - Material Stock Thru Final Machining

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Appendix A

FSW Process Parameter Development

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DOE for FSP/FSW of 6061-T651 Al

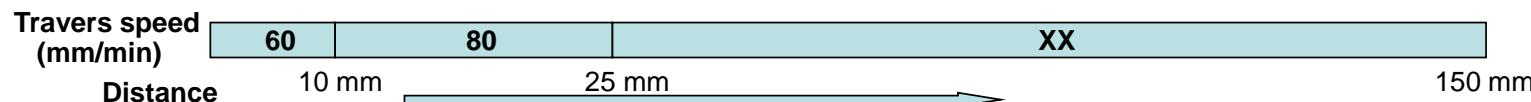
DOE 014

Operator:**Date: 04/13/11**

Substrate Material: 6061-T651 Al, 1" thick plate, 8 " × 2 " in size

| Tool Material | Tool pin geometry | Shoulder diameter (mm) | Pin length (mm) | Pin diameter (mm) | Pitch width (mm) |
|------------------|-------------------|------------------------|-----------------|-------------------|------------------|
| H13 steel, Rc 54 | Scrolled, conical | 38 | 25 | | |

| Tool plunging | Rotation rate (rpm) | Force (KN) | Feed rate (mm/min) | W (mm) | Z (mm) |
|------------------|---------------------|------------|--------------------|--------|--------|
| | 800 | 35 | 20 | - 24 | - 25 |



| Run Order (S.N.) | Rotation rate (rpm) | Traverse speed (mm/min) | Force (KN) | Actual Force (kN) | Tool tilt (degree) | Remarks on weld quality | |
|------------------|---------------------|-------------------------|------------|-------------------|--------------------|-------------------------|-------------|
| | | | | | | Macroscopic | Microscopic |
| 1(9) | 300 | 100 | 35 | 34 | 2 | | |
| 2(10) | 300 | 120 | 35 | 36 | 2 | | |
| 3(11) | 300 | 140 | 35 | 38 | 2 | | |
| 4(7) | 400 | 120 | 35 | 25 | 2 | | |
| 5(8) | 400 | 150 | 35 | 28 | 2 | | |

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DOE for FSP/FSW of 6061-T651 Al

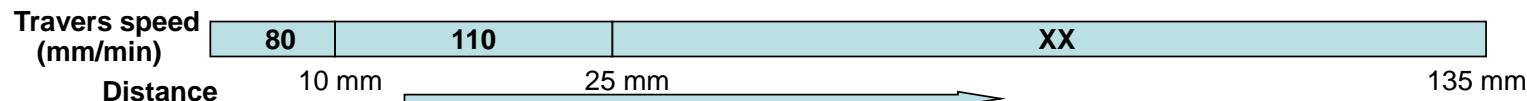
DOE 015

Operator:**Date: 04/28/11**

Substrate Material: 6061-T651 Al, 1" thick plate, 10 " × 2 " in size

| Tool Material | Tool pin geometry | Shoulder diameter (mm) | Pin length (mm) | Pin diameter (mm) | Pitch width (mm) |
|------------------|-------------------|------------------------|-----------------|-------------------|------------------|
| H13 steel, Rc 54 | Scrolled, conical | 50.8 | 24 | | |

| Tool plunging | Rotation rate (rpm) | Force (KN) | Feed rate (mm/min) | W (mm) | Z (mm) |
|------------------|---------------------|------------|--------------------|--------|--------|
| | 800 | 45 | 20 | - 24.2 | - 24.2 |



| Run Order (S.N.) | Rotation rate (rpm) | Traverse speed (mm/min) | Force (KN) | Actual Force (kN) | Tool tilt (degree) | Remarks on weld quality | |
|------------------|---------------------|-------------------------|------------|-------------------|--------------------|-------------------------|-------------|
| | | | | | | Macroscopic | Microscopic |
| 1(1) | 450 | 140 | 45 | 48 | 2 | No defect | |
| 2(2) | 450 | 160 | 45 | 50 | 2 | No defect | |
| 3 | 450 | 180 | 45 | | 2 | | |
| 4(3) | 500 | 140 | 45 | 48 | 2 | No defect | |
| 5(4) | 500 | 160 | 45 | 51 | 2 | No defect | |
| 6 | 500 | 180 | 45 | | 2 | | |
| 7 | 550 | 140 | 45 | | 2 | | |
| 8 | 550 | 160 | 45 | | 2 | | |
| 9 | 550 | 180 | 45 | | 2 | | |

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DOE for FSW of Al 5083-H131

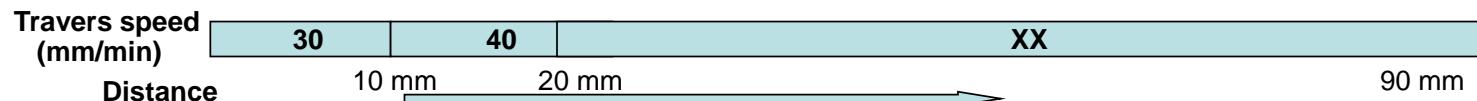
DOE 017

Operator:**Date: 06/08/11**

Substrate Material: Al 5083-H131 , 1" thick plate, 6 " × 2 " in size

| Tool Material | Tool pin geometry | Shoulder diameter (mm) | Pin length (mm) | Pin diameter (mm) | Pitch width (mm) |
|------------------|-------------------|------------------------|-----------------|-------------------|------------------|
| H13 steel, Rc 54 | Scrolled, conical | 40 | 24.17 | | |

| Tool plunging | Rotation rate (rpm) | Force (KN) | Feed rate (mm/min) | W (mm) | Z (mm) |
|------------------|---------------------|------------|--------------------|--------|---------|
| | 600 | 60 | 20 | - 24.0 | - 24.17 |



| Run Order (S.N.) | Rotation rate (rpm) | Traverse speed (mm/min) | Force (KN) | Actual Force (kN) | Tool tilt (degree) | Remarks on weld quality | |
|------------------|---------------------|-------------------------|------------|-------------------|--------------------|-------------------------|-------------|
| | | | | | | Macroscopic | Microscopic |
| 1 | 300 | 36 | 60 | 32-34 | 2 | | |
| 2 | 300 | 45 | 60 | 32-34 | 2 | | |
| 3 | 300 | 54 | 60 | 35-37 | 2 | | |
| 4 | 350 | 36 | 60 | 30-35 | 2 | | |
| 5 | 350 | 45 | 60 | 31-33 | 2 | | |
| 6 | 350 | 54 | 60 | 39-41 | 2 | | |
| 7 | 400 | 36 | 60 | 33-35 | 2 | | |
| 8 | 400 | 45 | 60 | 38-40 | 2 | | |
| 9 | 400 | 54 | 60 | 40-42 | 2 | | |

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DOE for FSW of Al 5083-H131

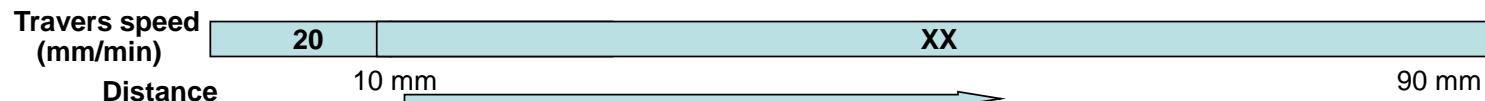
DOE 019

Operator:**Date: 06/22/11**

Substrate Material: Al 5083-H131 , 1" thick plate, 6 " × 2 " in size

| Tool Material | Tool pin geometry | Shoulder diameter (mm) | Pin length (mm) | Pin diameter (mm) | Pitch width (mm) |
|------------------|-------------------|------------------------|-----------------|-------------------|------------------|
| H13 steel, Rc 54 | Scrolled, conical | 40 | 24.17 | | |

| Tool plunging | Rotation rate (rpm) | Force (KN) | Feed rate (mm/min) | W (mm) | Z (mm) |
|------------------|---------------------|------------|--------------------|--------|---------|
| | 600 | 60 | 20 | - 24.0 | - 24.17 |



| Run Order (S.N.) | Rotation rate (rpm) | Traverse speed (mm/min) | Force (KN) | Actual Force (kN) | Tool tilt (degree) | Remarks on weld quality | |
|------------------|---------------------|-------------------------|------------|-------------------|--------------------|-------------------------|-------------|
| | | | | | | Macroscopic | Microscopic |
| 1 | 300 | 20 | 60 | 28-31 | 2 | | |
| 2 | 300 | 30 | 60 | 28-29 | 2 | | |
| 3 | 300 | 40 | 60 | 28-29 | 2 | | |
| 4 | 350 | 20 | 60 | 28-30 | 2 | | |
| 5 | 350 | 30 | 60 | 28-29 | 2 | | |
| 6 | 350 | 40 | 60 | 28-29 | 2 | | |
| 7 | 400 | 20 | 60 | 27-33 | 2 | | |
| 8 | 400 | 30 | 60 | 28-29 | 2 | | |
| 9 | 400 | 40 | 60 | 30-31 | 2 | | |

UNCLASSIFIED

UNCLASSIFIED

DOE for FSW of Al 5083-H131

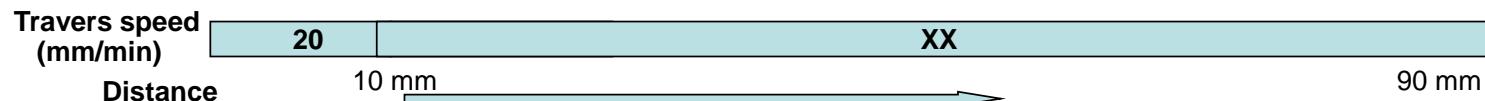
DOE 020

Operator:**Date: 06/23/11**

Substrate Material: Al 5083-H131 , 1" thick plate, 6 " × 2 " in size

| Tool Material | Tool pin geometry | Shoulder diameter (mm) | Pin length (mm) | Pin diameter (mm) | Pitch width (mm) |
|------------------|-------------------|------------------------|-----------------|-------------------|------------------|
| H13 steel, Rc 54 | Scrolled, conical | 40 | 24.17 | | |

| Tool plunging | Rotation rate (rpm) | Force (KN) | Feed rate (mm/min) | W (mm) | Z (mm) |
|------------------|---------------------|------------|--------------------|--------|---------|
| | 600 | 60 | 20 | - 24.0 | - 24.17 |



| Run Order (S.N.) | Rotation rate (rpm) | Traverse speed (mm/min) | Force (KN) | Actual Force (kN) | Tool tilt (degree) | Remarks on weld quality | |
|------------------|---------------------|-------------------------|------------|-------------------|--------------------|-------------------------|-------------|
| | | | | | | Macroscopic | Microscopic |
| 1 | 300 | 20 | 60 | | 3 | | |
| 2 | 300 | 30 | 60 | | 3 | | |
| 3 | 300 | 40 | 60 | | 3 | | |
| 4 | 350 | 20 | 60 | | 3 | | |
| 5 | 350 | 30 | 60 | | 3 | | |
| 6 | 350 | 40 | 60 | | 3 | | |
| 7 | 400 | 20 | 60 | | 3 | | |
| 8 | 400 | 30 | 60 | | 3 | | |
| 9 | 400 | 40 | 60 | | 3 | | |

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DOE for FSW of Al 5083-H131

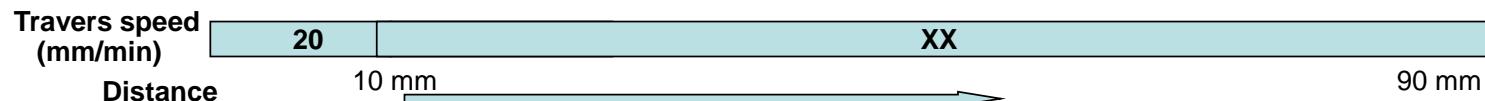
DOE 021

Operator:**Date: 06/24/11**

Substrate Material: Al 5083-H131 , 1" thick plate, 6 " × 2 " in size

| Tool Material | Tool pin geometry | Shoulder diameter (mm) | Pin length (mm) | Pin diameter (mm) | Pitch width (mm) |
|------------------|-------------------|------------------------|-----------------|-------------------|------------------|
| H13 steel, Rc 54 | Scrolled, conical | 40 | 24.17 | | |

| Tool plunging | Rotation rate (rpm) | Force (KN) | Feed rate (mm/min) | W (mm) | Z (mm) |
|------------------|---------------------|------------|--------------------|--------|---------|
| | 600 | 60 | 20 | - 24.0 | - 24.17 |



| Run Order (S.N.) | Rotation rate (rpm) | Traverse speed (mm/min) | Force (KN) | Actual Force (kN) | Tool tilt (degree) | Remarks on weld quality | |
|------------------|---------------------|-------------------------|------------|-------------------|--------------------|-------------------------|-------------|
| | | | | | | Macroscopic | Microscopic |
| 1 | 250 | 20 | 60 | 33 | 3 | | No defect |
| 2 | 250 | 25 | 60 | 33 | 3 | | No defect |
| 3 | 250 | 30 | 60 | 33 | 3 | | No defect |
| 4 | 300 | 20 | 60 | 34 | 3 | | No defect |
| 5 | 300 | 25 | 60 | 33 | 3 | Best Parameter | No defect |
| 6 | 300 | 30 | 60 | 33 | 3 | | No defect |
| 7 | 350 | 20 | 60 | 30 | 3 | | No defect |
| 8 | 350 | 25 | 60 | 31 | 3 | | No defect |
| 9 | 350 | 30 | 60 | 33 | 3 | | No defect |

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DOE for FSW of Al 2139-T8

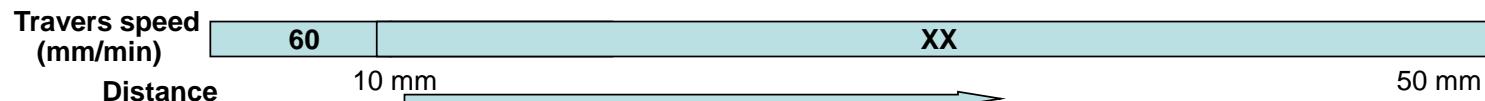
DOE 022

Operator:**Date: 09/26/11**

Substrate Material: Al 2139-T8, 1" thick plate, 8 " × 2 " in size

| Tool Material | Tool pin geometry | Shoulder diameter (mm) | Pin length (mm) | Pin diameter (mm) | Pitch width (mm) |
|------------------|-------------------|------------------------|-----------------|-------------------|------------------|
| H13 steel, Rc 54 | Scrolled, conical | 50.8 | 24.05 | | |

| Tool plunging | Rotation rate (rpm) | Force (KN) | Feed rate (mm/min) | W (mm) | Z (mm) |
|------------------|---------------------|------------|--------------------|---------|---------|
| | 600 | 60 | 20 | - 24.05 | - 24.05 |



| Run Order (S.N.) | Rotation rate (rpm) | Traverse speed (mm/min) | Force (KN) | Actual Force (kN) | Tool tilt (degree) | Remarks on weld quality | |
|------------------|---------------------|-------------------------|------------|-------------------|--------------------|-------------------------|-------------|
| | | | | | | Macroscopic | Microscopic |
| 1 | 400 | 100 | 50 | 63 | 2 | | |
| 2 | 400 | 70 | 60 | 69 | 2 | | |
| 3 | 350 | 100 | 60 | 87 | 2 | | |
| 4 | | | | | | | |
| 5 | | | | | | | |
| 6 | | | | | | | |
| 7 | | | | | | | |
| 8 | | | | | | | |
| 9 | | | | | | | |

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DOE for FSW of Al 2139-T8

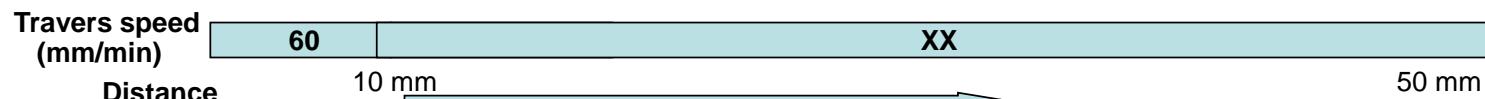
DOE 023

Operator:**Date: 09/26/11**

Substrate Material: Al 2139-T8, 1" thick plate, 8 " × 2 " in size

| Tool Material | Tool pin geometry | Shoulder diameter (mm) | Pin length (mm) | Pin diameter (mm) | Pitch width (mm) |
|------------------|-------------------|------------------------|-----------------|-------------------|------------------|
| H13 steel, Rc 54 | Scrolled, conical | 40 | 24.17 | | |

| Tool plunging | Rotation rate (rpm) | Force (KN) | Feed rate (mm/min) | W (mm) | Z (mm) |
|------------------|---------------------|------------|--------------------|---------|---------|
| | 600 | 60 | 20 | - 24.17 | - 24.17 |



| Run Order (S.N.) | Rotation rate (rpm) | Traverse speed (mm/min) | Force (KN) | Actual Force (kN) | Tool tilt (degree) | Remarks on weld quality | |
|------------------|---------------------|-------------------------|------------|-------------------|--------------------|-------------------------|-------------|
| | | | | | | Macroscopic | Microscopic |
| 1 | 350 | 80 | 60 | 58 | 3 | Wormhole | |
| 2 | 300 | 60 | 60 | 57 | 3 | Wormhole | |
| 3 | 300 | 80 | 60 | 59 | 3 | Wormhole | |
| 4 | 250 | 60 | 60 | 50 | 3 | Wormhole | |
| 5 | 250 | 40 | 60 | 45 | 3 | No defect | |

UNCLASSIFIED

UNCLASSIFIED

DOE for FSW of Al 2139-T8

DOE 024

Operator:

Date: 09/28/11

Substrate Material: Al 2139-T8, 1" thick plate, 8 " × 2 " in size

| Tool Material | Tool pin geometry | Shoulder diameter (mm) | Pin length (mm) | Pin diameter (mm) | Pitch width (mm) |
|------------------|-------------------|------------------------|-----------------|-------------------|------------------|
| H13 steel, Rc 54 | Scrolled, conical | 40 | 24.33 | | |

| Tool plunging | Rotation rate (rpm) | Force (KN) | Feed rate (mm/min) | W (mm) | Z (mm) |
|------------------|---------------------|------------|--------------------|---------|---------|
| | 600 | 60 | 20 | - 24.35 | - 24.35 |



| Run Order (S.N.) | Rotation rate (rpm) | Traverse speed (mm/min) | Force (KN) | Actual Force (kN) | Tool tilt (degree) | Remarks on weld quality | |
|------------------|---------------------|-------------------------|------------|-------------------|--------------------|-------------------------|-------------|
| | | | | | | Macroscopic | Microscopic |
| 1 | 250 | 30 | 60 | 39-43 | 3 | | No defect |
| 2 | 250 | 40 | 60 | 40-45 | 3 | Best Parameters | No defect |
| 3 | 250 | 50 | 60 | 42-48 | 3 | | No defect |

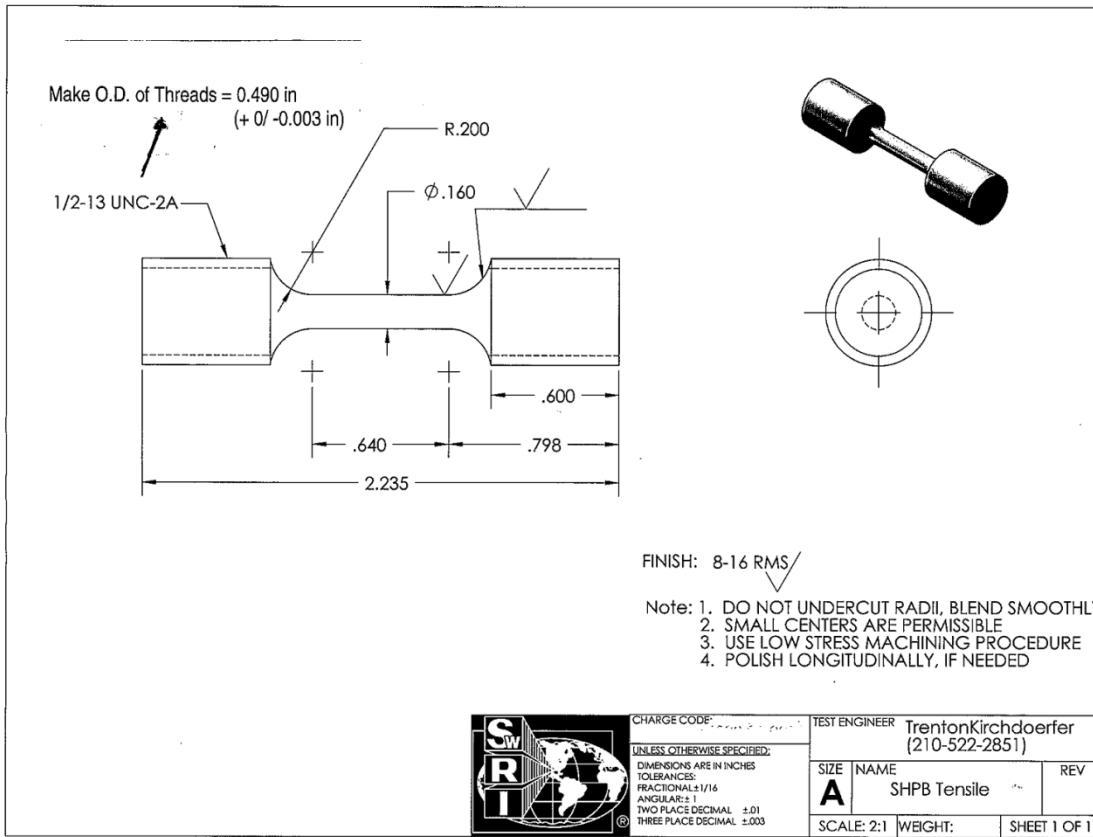
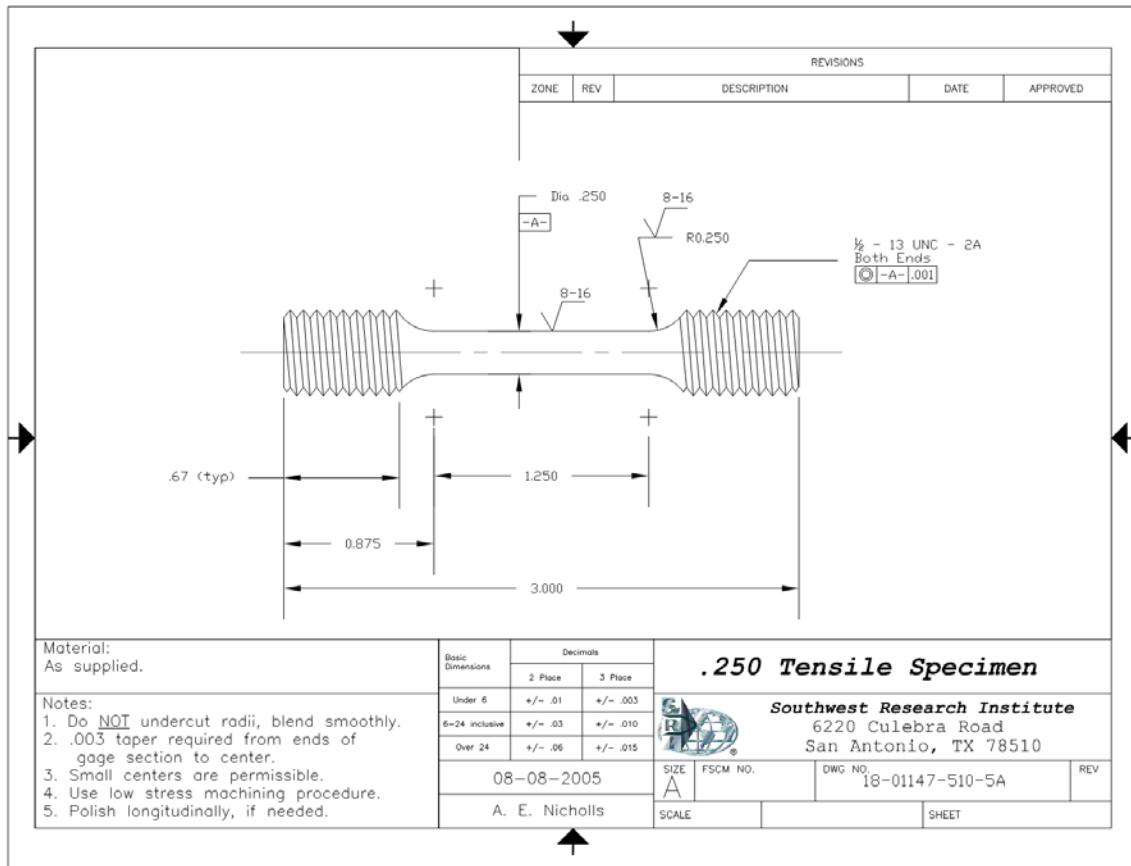
UNCLASSIFIED

UNCLASSIFIED

Appendix B

J-C Test Specimen Prints

UNCLASSIFIED



UNCLASSIFIED

| UNCLASSIFIED | | | | LTR | DESCRIPTION | DATE | APPROVED | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|-----------|--|--|---|---|------|----------|-----------|-----------|-------------|----------------|-------------------------|-----------------------------|----------|--|------------|--|--|--|--|--|--|--|---|--|--|--|---|---|--|--|-----------|--|--|--|--|--|--|--|------|-----|-------------|--|--|------|----------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| <p>-A- // -A-.001 B-B .750 φ.375 T-A-.001</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| NOTE: USE LOW STRESS MACHINING PROCEDURE | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">ITEM NO.</th> <th style="width: 15%;">QTY. REQ.</th> <th style="width: 15%;">SIZE</th> <th style="width: 15%;">CODE IDENT NO.</th> <th style="width: 15%;">PART OR IDENTIFYING NO.</th> <th colspan="3" style="width: 30%;">NOMENCLATURE OR DESCRIPTION</th> </tr> </thead> <tbody> <tr> <td colspan="8" style="text-align: center; font-weight: bold;">PARTS LIST</td> </tr> <tr> <td rowspan="5" style="width: 15%; vertical-align: top;"> MATERIAL FINISH <small>USED ON</small> <small>QTY. REQD.</small> </td> <td rowspan="5" style="width: 15%; vertical-align: top;"></td> <td rowspan="5" style="width: 15%; vertical-align: top;"> BASIC DIMENSIONS 2 PLACE 3 PLACE SMALLER $\pm .01$ $\pm .003$ $\pm 1/32$ OVER 8 $\pm .03$ $\pm .018$ $\pm 1/16$ OVER 24 $\pm .08$ $\pm .035$ $\pm 1/8$ HOLDS $\pm 0.50^\circ$ $\pm 1^\circ$ </td> <td rowspan="5" style="width: 15%; vertical-align: top;"> FRAG. TIONS 2 PLACE 3 PLACE DRAWN $\pm .003$ $\pm 1/32$ ORIG $\pm .018$ $\pm 1/16$ MECH $\pm .035$ $\pm 1/8$ ELECT $\pm 0.50^\circ$ $\pm 1^\circ$ </td> <td rowspan="5" style="width: 15%; vertical-align: top;"> CONTRACT DWG J-11-2000 A.NAGY </td> <td colspan="3" rowspan="5" style="width: 30%; vertical-align: top; text-align: center;"> SOUTHWEST RESEARCH INSTITUTE .375 COMPRESSION SPECIMEN DRAWING NO. 18-01147-510-B SCALE 1 SHEET </td> </tr> <tr> <td colspan="8" style="text-align: center; font-weight: bold;">REVISIONS</td> </tr> <tr> <td style="width: 15%;">ZONE</td> <td style="width: 15%;">REV</td> <td colspan="3" style="width: 30%;">DESCRIPTION</td> <td style="width: 15%;">DATE</td> <td style="width: 15%;">APPROVED</td> </tr> <tr> <td colspan="8" style="text-align: center; height: 20px;"></td> </tr> <tr> <td colspan="8" style="text-align: center; height: 20px;"></td> </tr> </tbody> </table> | | | | | | | | ITEM NO. | QTY. REQ. | SIZE | CODE IDENT NO. | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | | | PARTS LIST | | | | | | | | MATERIAL FINISH <small>USED ON</small> <small>QTY. REQD.</small> | | BASIC DIMENSIONS 2 PLACE 3 PLACE SMALLER $\pm .01$ $\pm .003$ $\pm 1/32$ OVER 8 $\pm .03$ $\pm .018$ $\pm 1/16$ OVER 24 $\pm .08$ $\pm .035$ $\pm 1/8$ HOLDS $\pm 0.50^\circ$ $\pm 1^\circ$ | FRAG. TIONS 2 PLACE 3 PLACE DRAWN $\pm .003$ $\pm 1/32$ ORIG $\pm .018$ $\pm 1/16$ MECH $\pm .035$ $\pm 1/8$ ELECT $\pm 0.50^\circ$ $\pm 1^\circ$ | CONTRACT DWG J-11-2000 A.NAGY | SOUTHWEST RESEARCH INSTITUTE .375 COMPRESSION SPECIMEN DRAWING NO. 18-01147-510-B SCALE 1 SHEET | | | REVISIONS | | | | | | | | ZONE | REV | DESCRIPTION | | | DATE | APPROVED | | | | | | | | | | | | | | | | |
| ITEM NO. | QTY. REQ. | SIZE | CODE IDENT NO. | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| PARTS LIST | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MATERIAL FINISH <small>USED ON</small> <small>QTY. REQD.</small> | | BASIC DIMENSIONS 2 PLACE 3 PLACE SMALLER $\pm .01$ $\pm .003$ $\pm 1/32$ OVER 8 $\pm .03$ $\pm .018$ $\pm 1/16$ OVER 24 $\pm .08$ $\pm .035$ $\pm 1/8$ HOLDS $\pm 0.50^\circ$ $\pm 1^\circ$ | FRAG. TIONS 2 PLACE 3 PLACE DRAWN $\pm .003$ $\pm 1/32$ ORIG $\pm .018$ $\pm 1/16$ MECH $\pm .035$ $\pm 1/8$ ELECT $\pm 0.50^\circ$ $\pm 1^\circ$ | CONTRACT DWG J-11-2000 A.NAGY | SOUTHWEST RESEARCH INSTITUTE .375 COMPRESSION SPECIMEN DRAWING NO. 18-01147-510-B SCALE 1 SHEET | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | REVISIONS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | ZONE | REV | DESCRIPTION | | | DATE | APPROVED | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Material: | | Basic Dimensions 2 Places 3 Places | | T.A.I.T Specimen Southwest Research Institute 6220 Culebra Road San Antonio, TX 78510 | | | |
|------------------------------|--|--|--|--|--------------------------|--|--|
| | | | | | | | |
| Notes: | | Under 8 | $\pm .01$ | $\pm .003$ | | | |
| | | 8-24 inclusive | $\pm .03$ | $\pm .010$ | | | |
| | | Over 24 | $\pm .08$ | $\pm .035$ | | | |
| 10-11-2005 A. E. Nicholls | | SIZE A | FSCM NO. 18-01147-510-B | DWG NO. J-11-2000 | REV 1 | | |
| SCALE 1 | | 1 | | | SHEET 1 | | |

UNCLASSIFIED

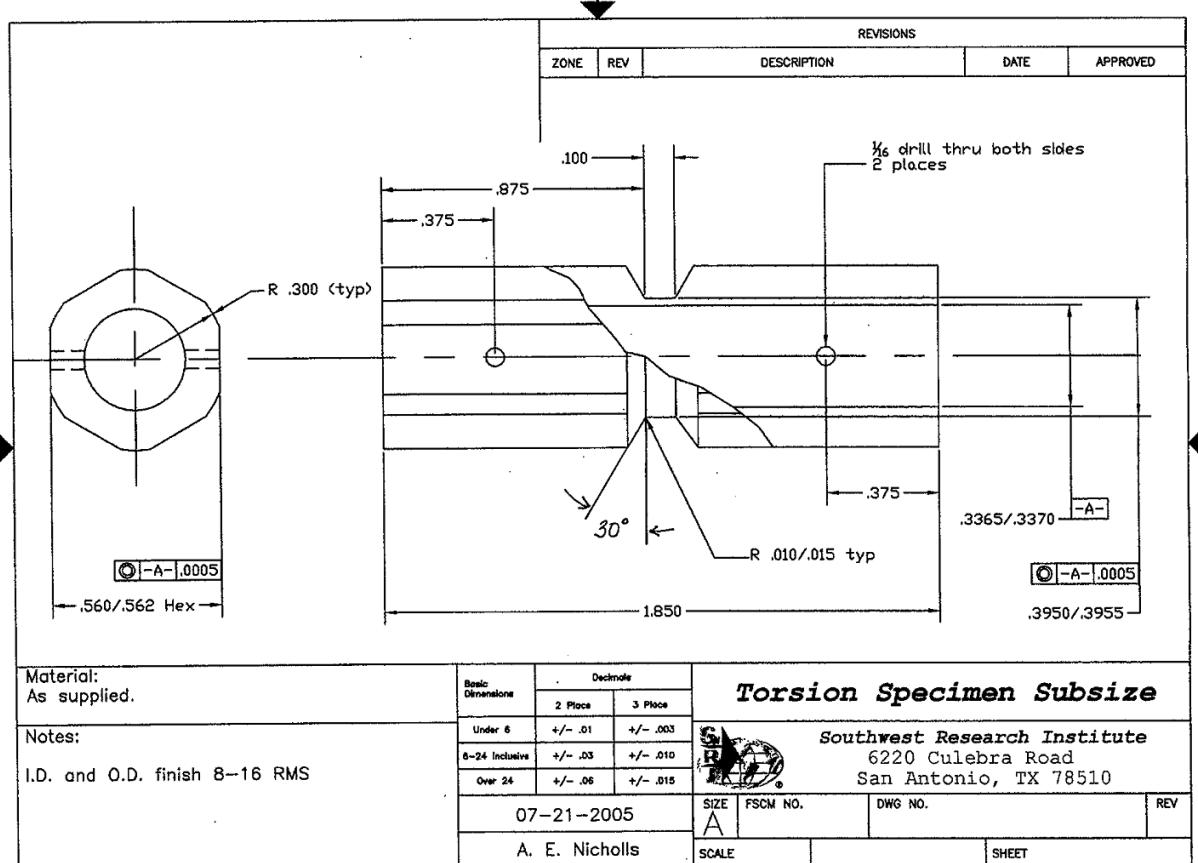
| | | | |
|--|-----------------|------|----------|
| L/TN | DESCRIPTION | DATE | APPROVED |
| | LENGTH WAS 5.50 | | |
| <p style="text-align: center;">3/4 - 10 UNC - 2A BOTH ENDS [TOLERANCE]</p> | | | |
| <p>NOTE: 1. SMALL CENTERS ARE PERMISSIBLE 2. USE LOW STRESS MACHINING PROCEDURE</p> | | | |

| | | FIND NO. | QTY REQ. | M | CODE | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | | | | | | |
|--|--|----------|----------|------------------|------|-------------------------|-----------------------------|----------|----------|----------|------------------------------|----------------|--------|
| | | | | | | | PARTS LIST | | | | | | |
| | | MATERIAL | | BASIC DIMENSIONS | | DECIMALS | | FRACTION | | CONTRACT | | | |
| | | | | | | 2 PLACE | 3 PLACE | OWN | 8-B-2000 | A.NAGY | SOUTHWEST RESEARCH INSTITUTE | | |
| | | | | | | UNDER 6 | .01 | .003 | 3 1/32 | | "B" NOTCH TENSILE SPECIMEN | | |
| | | | | | | 6-24 INCL | .03 | .010 | 3 1/16 | | | | |
| | | | | | | OVER 24 | .06 | .015 | 3 1/8 | | | | |
| | | | | | | ANGLES | | .0° 30° | 3 1° 0' | | | | |
| | | | | | | E:120001DMPA1BNOTCH | | | | | DRAWING NO. | 18-01147-510-3 | REV. J |
| | | | | | | | | | | | SCALE f=f | SHEET | |

| | | | |
|--|-----------------|------|----------|
| L/TN | DESCRIPTION | DATE | APPROVED |
| | LENGTH WAS 5.50 | | |
| <p style="text-align: center;">3/4 - 10 UNC - 2A BOTH ENDS [TOLERANCE]</p> | | | |
| <p>NOTE: 1. SMALL CENTERS ARE PERMISSIBLE 2. USE LOW STRESS MACHINING PROCEDURE</p> | | | |

| | | FIND NO. | QTY REQ. | M | CODE | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | | | | | | |
|--|--|----------|----------|------------------|------|-------------------------|-----------------------------|----------|-----------|----------|------------------------------|----------------|--------|
| | | | | | | | PARTS LIST | | | | | | |
| | | MATERIAL | | BASIC DIMENSIONS | | DECIMALS | | FRACTION | | CONTRACT | | | |
| | | | | | | 2 PLACE | 3 PLACE | OWN | J-10-2000 | A.NAGY | SOUTHWEST RESEARCH INSTITUTE | | |
| | | | | | | UNDER 6 | .01 | .003 | 3 1/32 | | "E" NOTCH TENSILE SPECIMEN | | |
| | | | | | | 6-24 INCL | .03 | .010 | 3 1/16 | | | | |
| | | | | | | OVER 24 | .06 | .015 | 3 1/8 | | | | |
| | | | | | | ANGLES | | .0° 30° | 3 1° 0' | | | | |
| | | | | | | E:120001DMPA1BNOTCH | | | | | DRAWING NO. | 18-01147-510-4 | REV. J |
| | | | | | | | | | | | SCALE f=f | SHEET | |

UNCLASSIFIED



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Appendix C

FH-CAT Machining Processes

UNCLASSIFIED

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Focus: HOPE Process routing/Shop travelerCustomer: **Southwest Research Institute**

Street Address:

City State Zip:

Stock: **4 x 4 1/2 x 1 coupon (8)**

Part Number:

Description: **Johnson-Cook Test Specimen Blocks 6061/5083**

Revision:

| Op No | Labor Code | Operation Description |
|-------|----------------------|---|
| 10 | Height Gage & Scribe | Find, and scribe weld centerline on ends of block. |
| 20 | Mill | Mill TOP to 0.875 |
| 30 | Laser Marker | Mark TOP face of coupon per print (MMMM-X-TOP-NN, Where X=A,W, or R) |
| 40 | Mill | Mill BOTTOM to 0.750 thick |
| 50 | Mill | Mill coupon to 1.38 from weld centerline (retreating side) |
| 60 | Band Saw | Saw Block W .475 (minimum) from weld centerline (retreating side) SET ASIDE CUT OFF BLOCK "R" |
| 70 | Mill | Mill coupon to .375 from weld centerline (retreating side) |
| 80 | Mill | Flip around (TOP still facing up) and mill coupon to 1.75 |
| 90 | Band Saw | Saw block at 'A' to .850 and remaining strip 'W' at .900 ref |
| 100 | Mill | Mill 'W' to .750 (from saw cut side) |
| 110 | Mill | Mill R to .750 (From saw cut side) |
| 120 | Mill | Mill A to .750 (from saw cut side) |
| 130 | | Measurement of finished blocks, per inspection check sheet |
| | | |

UNCLASSIFIED

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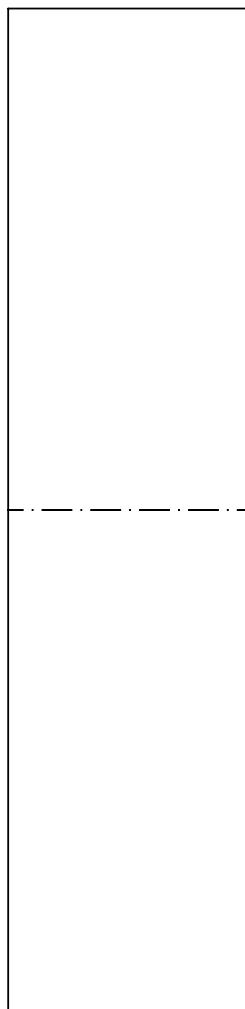
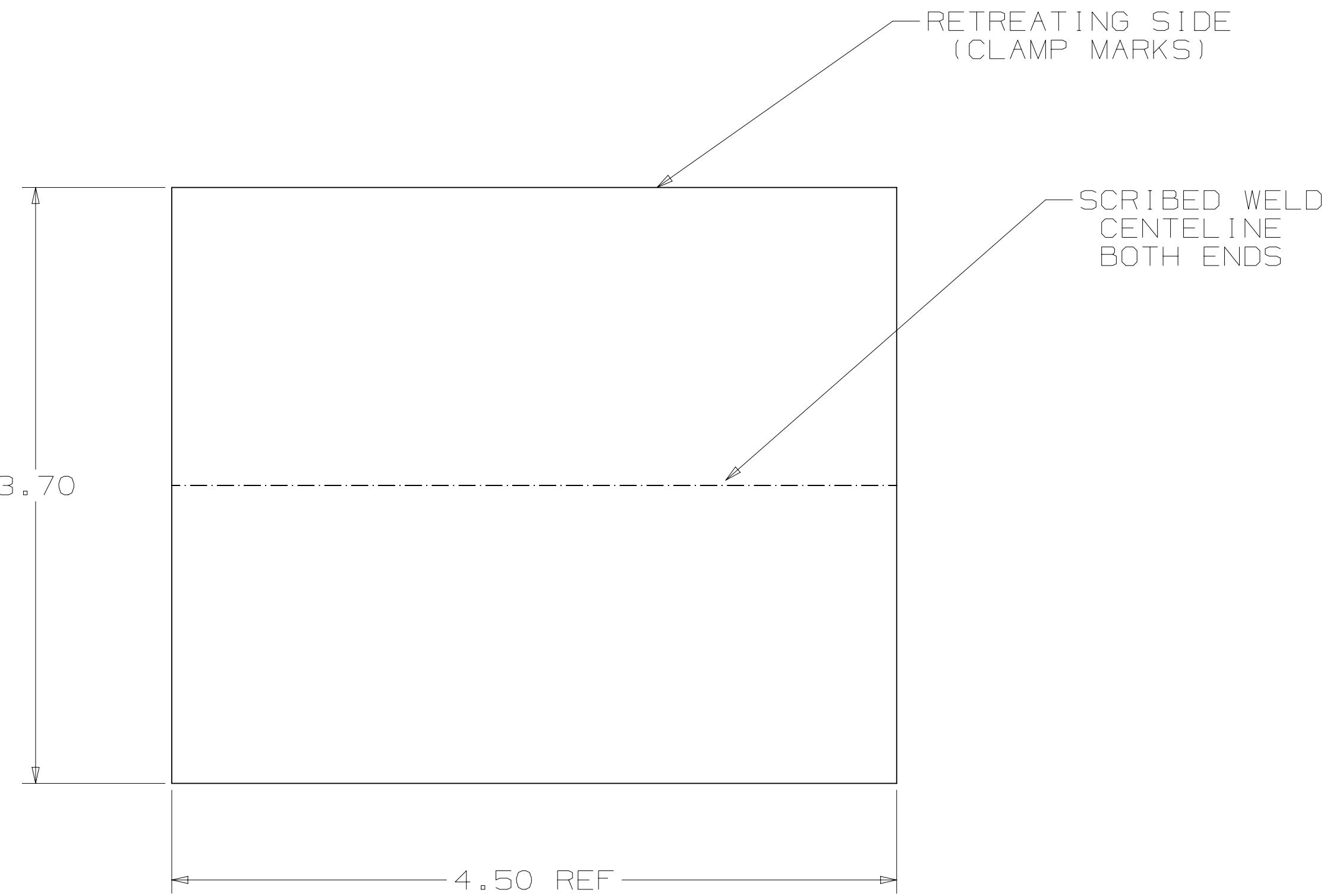
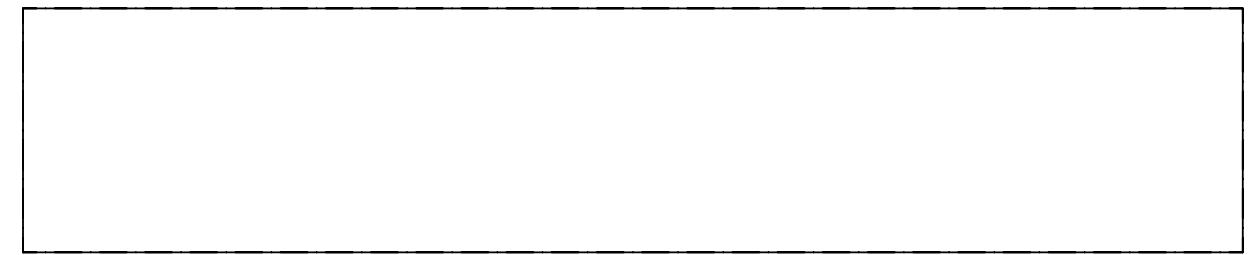
4

3

2

1

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |



| TOLERANCES | |
|---------------|--------|
| DECIMALS | |
| 1 PLACE | ± .045 |
| 2 PLACE | ± .030 |
| 3 PLACE | ± .015 |
| 4 PLACE | ± .005 |

ANGULAR
± 0° 30'

FRACTIONS
± 1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL : 5083 ALUMINUM

| | | | | | | | |
|-------------------|------------------------------|--------------------|---------|----------|-----------------------------|-----------|-----|
| CHANGE RESTRICTED | DO NOT SCALE | | | | | | |
| USAGE : | FOCUS: HOPE MANUFACTURING | | | | | | |
| ARMY - FSP | THIRD ANGLE PROJECTION | | | | | | |
| PART NAME | | J C TESTING STRIPS | | | | | |
| DRAWN BY | B.T. | DATE | 9/23/11 | DWG NO. | J_C TESTING_STRIPS_IP10_DWG | | |
| CHECKED BY | R.Z. | DATE | 9/23/11 | PART NO. | | | |
| RELEASED BY | | UNITS | N/A | SCALE | N/A | SIZE | C |
| | | INCHES | | REV | | DWG LEVEL | 100 |
| | | | | SHEET | 1 | OF | 1 |

4

3

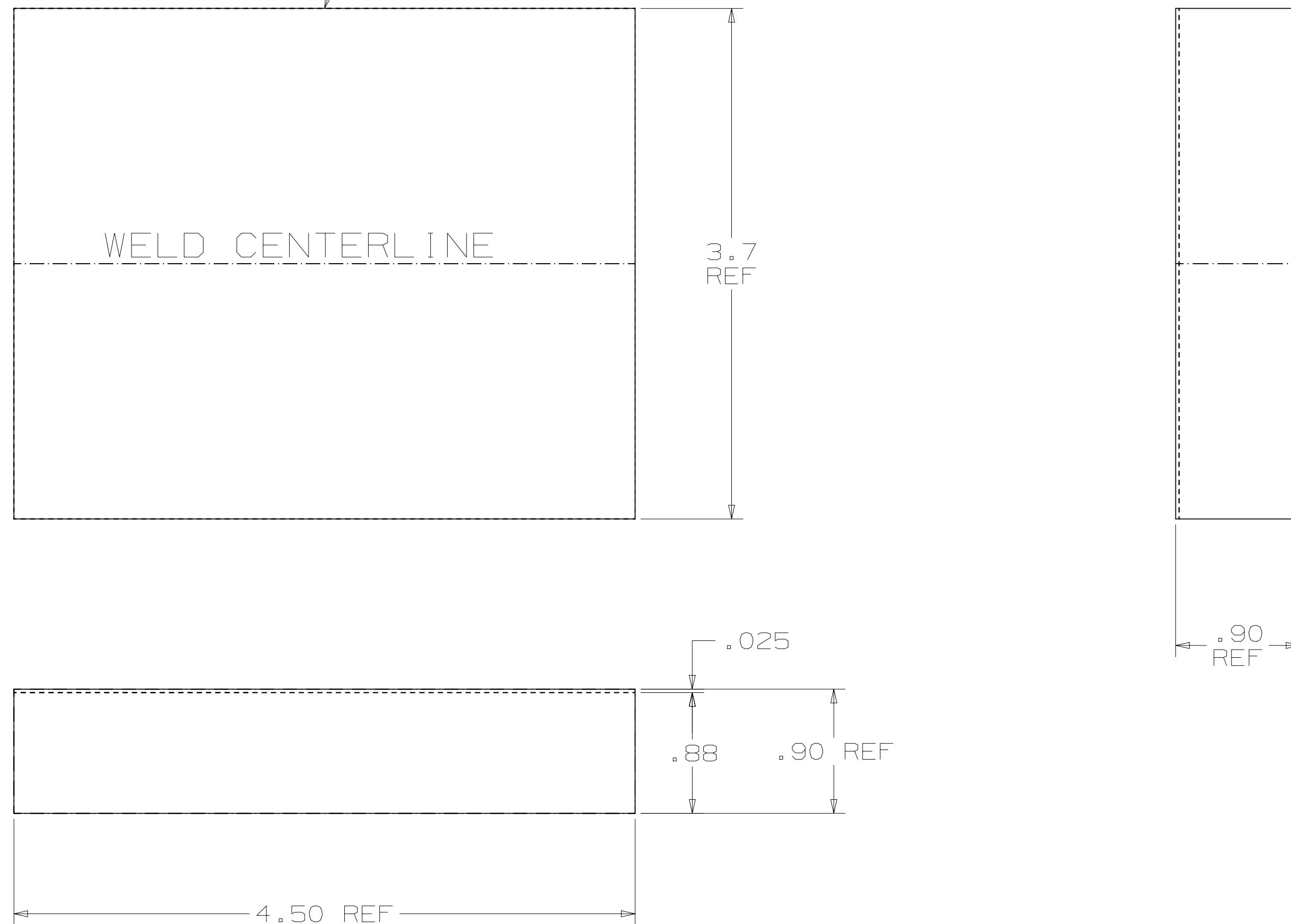
2

1

UNCLASSIFIED

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
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RETREATING SIDE
(CLAMP MARKS)



TOLERANCES

DECIMALS

- 1 PLACE $\pm .045$
2 PLACE $\pm .030$
3 PLACE $\pm .015$
4 PLACE $\pm .005$

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 5083 ALUMINUM

ANGULAR
 $\pm 0^\circ 30'$ FRACTIONS
 $\pm 1/16$ IP20
DWG

| | |
|----------------------|--|
| CHANGE RESTRICTED | DO NOT SCALE |
| USAGE: ARMY - FSP | FOCUS: HOPE MANUFACTURING THIRD ANGLE PROJECTION |
| DRAWN BY B.T. | DATE 9/23/11 |
| CHECKED BY R.Z. | DATE 9/23/11 |
| RELEASED BY | UNITS INCHES |
| | SCALE N/A |
| | SIZE C |
| | DWG LEVEL 100 |
| | REV |
| | SHEET 1 OF 1 |

DWG NO: J_C_TESTING_STRIPS_IP20_DWG
PART NO: J_C_TESTING_STRIPS
DWG LEVEL: 100
REV: 1
SHEET 1 OF 1

UNCLASSIFIED

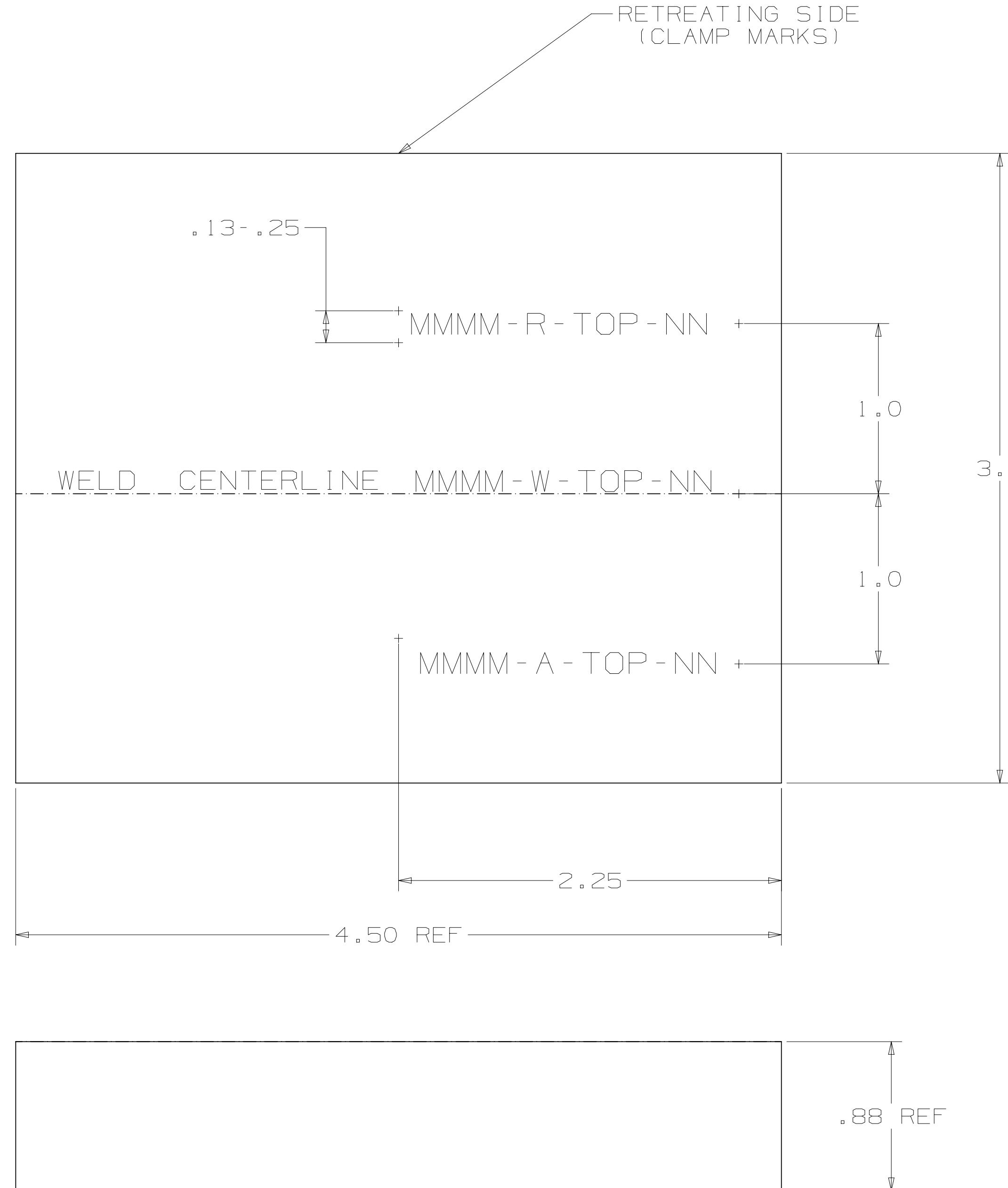
4

3

2

1

UNCLASSIFIED



MMMM = 5083

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
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| | | | | | | | | |

| DECIMALS | | TOLERANCES |
|--------------|------|------------------------------|
| 1 PLACE..... | .045 | ANGULAR $\pm 0^\circ 30'$ |
| 2 PLACE..... | .030 | FRACTIONS $\pm 1/16$ |
| 3 PLACE..... | .015 | |
| 4 PLACE..... | .005 | |

UNLESS OTHERWISE SPECIFIED
BREAK ALL SHARP EDGES
MATERIAL: 5083 ALUMINUM

IP30
DWG

| CHANGE RESTRICTED | DO NOT SCALE | FOCUS: HOPE MANUFACTURING |
|-------------------|-----------------|---------------------------|
| USAGE: | ARMY - FSP | THIRD ANGLE PROJECTION |
| DRAWN BY | B.T. | DATE |
| | | 9/23/11 |
| CHECKED BY | R.Z. | DATE |
| | | 9/23/11 |
| RELEASED BY | UNITS INCHES | SCALE N/A |
| | | SIZE C |
| | | DWG LEVEL 100 |
| | | REV 1 |
| | | SHEET 1 OF 1 |

4

11

2

1

MMMM - R - TOP - NN

WELD CENTERLINE

MMMM - W - TOP - NN

MMMM - A - TOP - NN

3.7
REF

4 . 50 REF

.750 □ 12

A decorative horizontal border at the bottom of the page, consisting of a series of diagonal lines that create a hatched or striped effect.

A technical drawing showing a vertical dimension line with arrows at both ends, indicating a height of 750 units. The dimension line is positioned between two horizontal reference lines. The value '750' is written in the center of the dimension line, with a small square symbol preceding it.

TO FRANCES

1 PLACE ± . 045
2 PLACE ± . 030
3 PLACE ± . 015
4 PLACE ± . 005

ANGULAR
 $\pm 0^\circ 30'$

FRACTIONS

+ 1/16

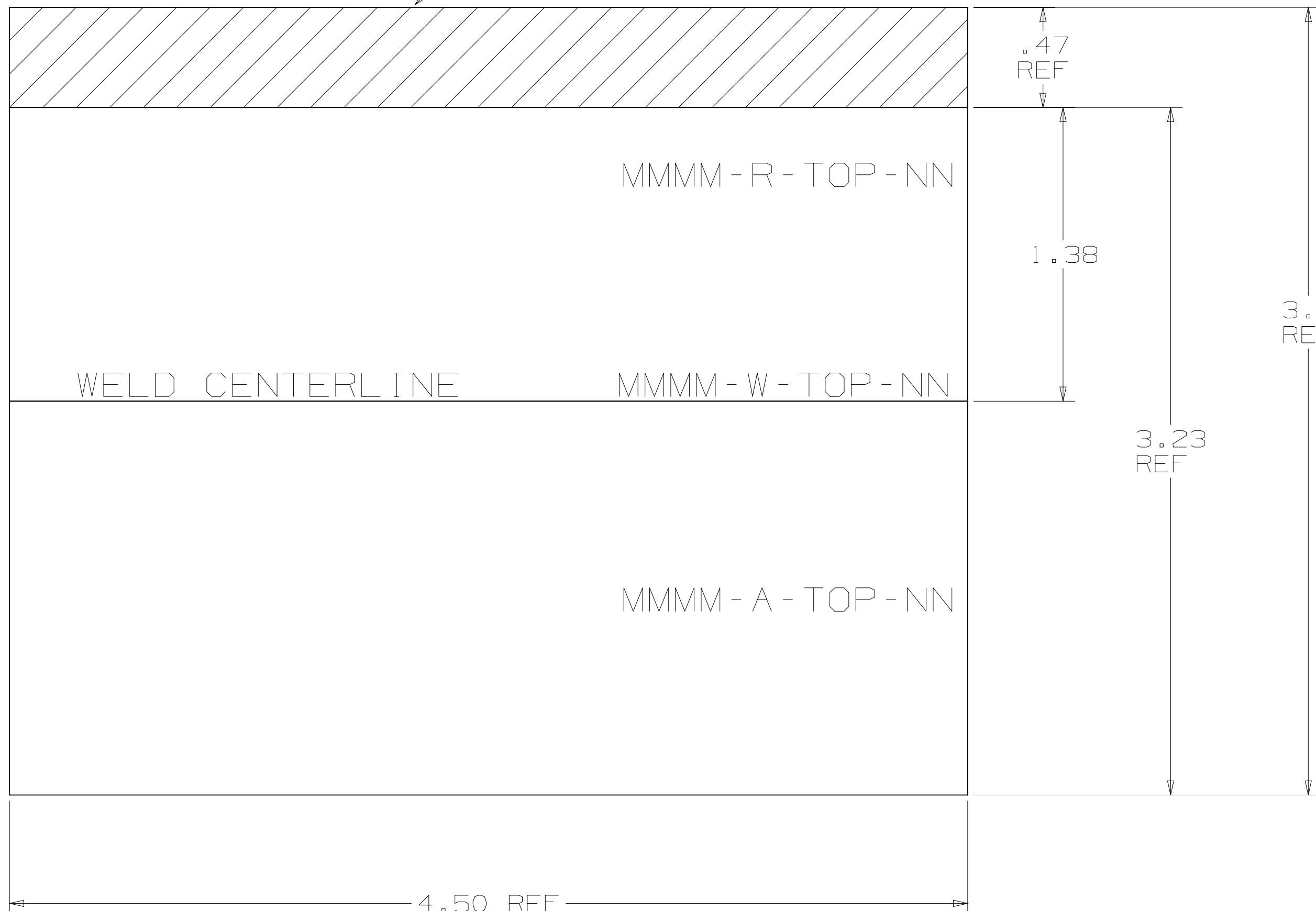
UNI FESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL : 5083 ALUMINUM

| | | | | | | |
|------------------------------|-----------------|---|-----------|--|-----|--------------|
| U.G CHANGE RESTRICTED | | DO NOT SCALE | | | | |
| USAGE: ARMY - FSP | |   THIRD ANGLE PROJECTION | | FOCUS: HOPE MANUFACTURING | | |
| | | PART NAME | | J C TESTING STRIPS | | |
| DRAWN BY B.T. | DATE 9/23/11 | DWG NO. J_C_TESTING_STRIPS_IP40_DWG | | | | |
| CHECKED BY R.Z. | 9/23/11 | PART NO. | | | | |
| RELEASED BY | UNITS INCHES | SCALE N/A | SIZE C | DWG LEVEL 100 | REV | SHEET 1 OF 1 |

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
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| | | | | | | | | |

CLAMP
MARKS

TOLERANCES

DECIMALS

- 1 PLACE..... ± .045
- 2 PLACE..... ± .030
- 3 PLACE..... ± .015
- 4 PLACE..... ± .005

ANGULAR

± 0° 30'
± 1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

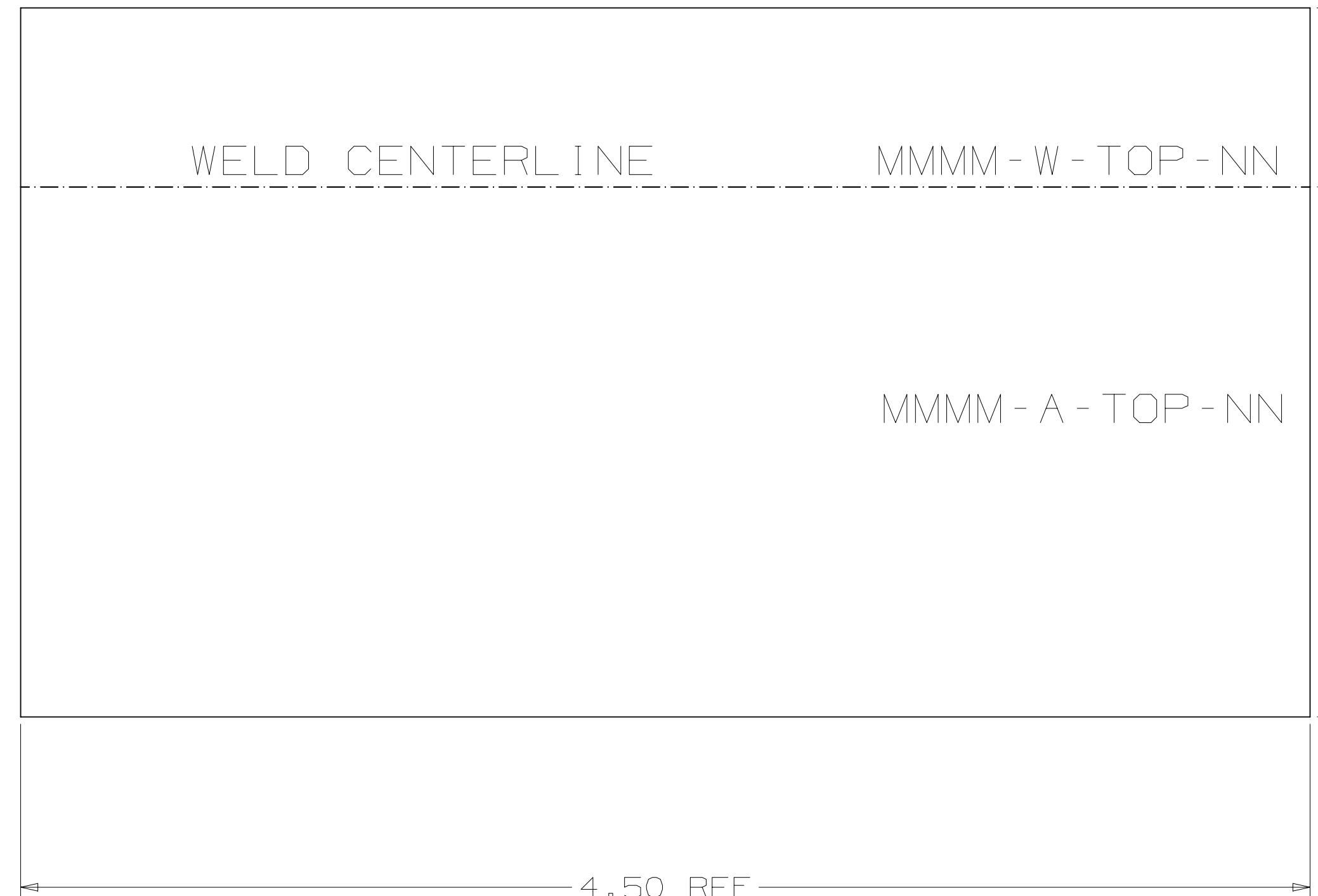
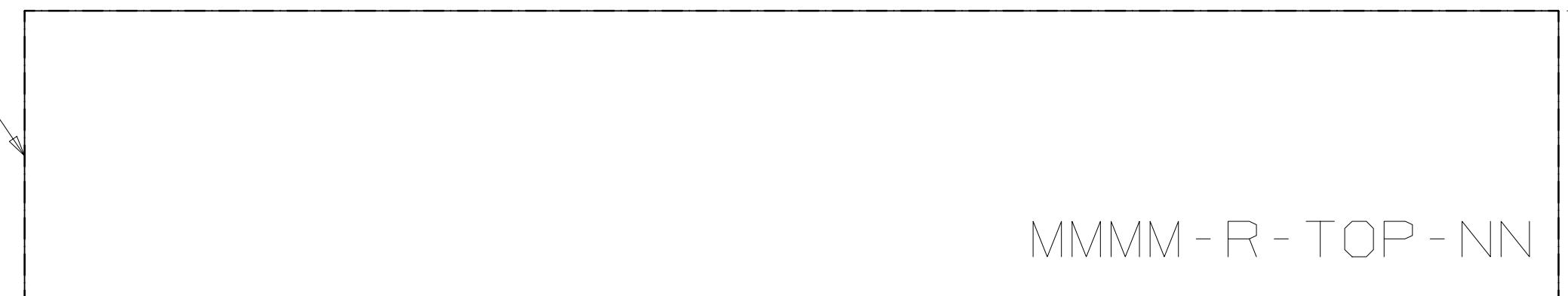
MATERIAL: 5083 ALUMINUM

IP50
DWG

| | | | |
|-----------------------------|--------------|--------------------------------------|--------------|
| WG CHANGE RESTRICTED | | DO NOT SCALE | |
| USAGE: ARMY - FSP | | FOCUS: HOPE MANUFACTURING | |
| DRAWN BY B.T. 9/23/11 | | DWG NO. J_C TESTING STRIPS | |
| CHECKED BY R.Z. 9/23/11 | | PART NO. J_C TESTING STRIPS_IP50_DWG | |
| RELEASED BY | UNITS INCHES | SCALE N/A | SIZE C |
| | | DWG LEVEL 100 | REV |
| | | | SHEET 1 OF 1 |

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
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RESULT OF CUT OFF



TOLERANCES

DECIMALS

- 1 PLACE $\pm .045$
- 2 PLACE $\pm .030$
- 3 PLACE $\pm .015$
- 4 PLACE $\pm .005$

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 5083 ALUMINUM

ANGULAR
 $\pm 0^\circ 30'$

FRACTIONS
 $\pm 1/16$

| | | | |
|-----------------------------|------|-------------------------------|-----------------------------|
| WG CHANGE RESTRICTED | | DO NOT SCALE | |
| USAGE: | | FOCUS: HOPE MANUFACTURING | |
| ARMY - FSP | | PART NAME: J C TESTING STRIPS | |
| DRAWN BY | B.T. | DATE | DWG NO. |
| CHECKED BY | R.Z. | 9/23/11 | J_C TESTING_STRIPS_IP60_DWG |
| RELEASED BY | | UNITS INCHES | SCALE N/A |
| | | SIZE C | DWG LEVEL 100 |
| | | REV | SHEET 1 OF 1 |

IP60
DWG

UNCLASSIFIED

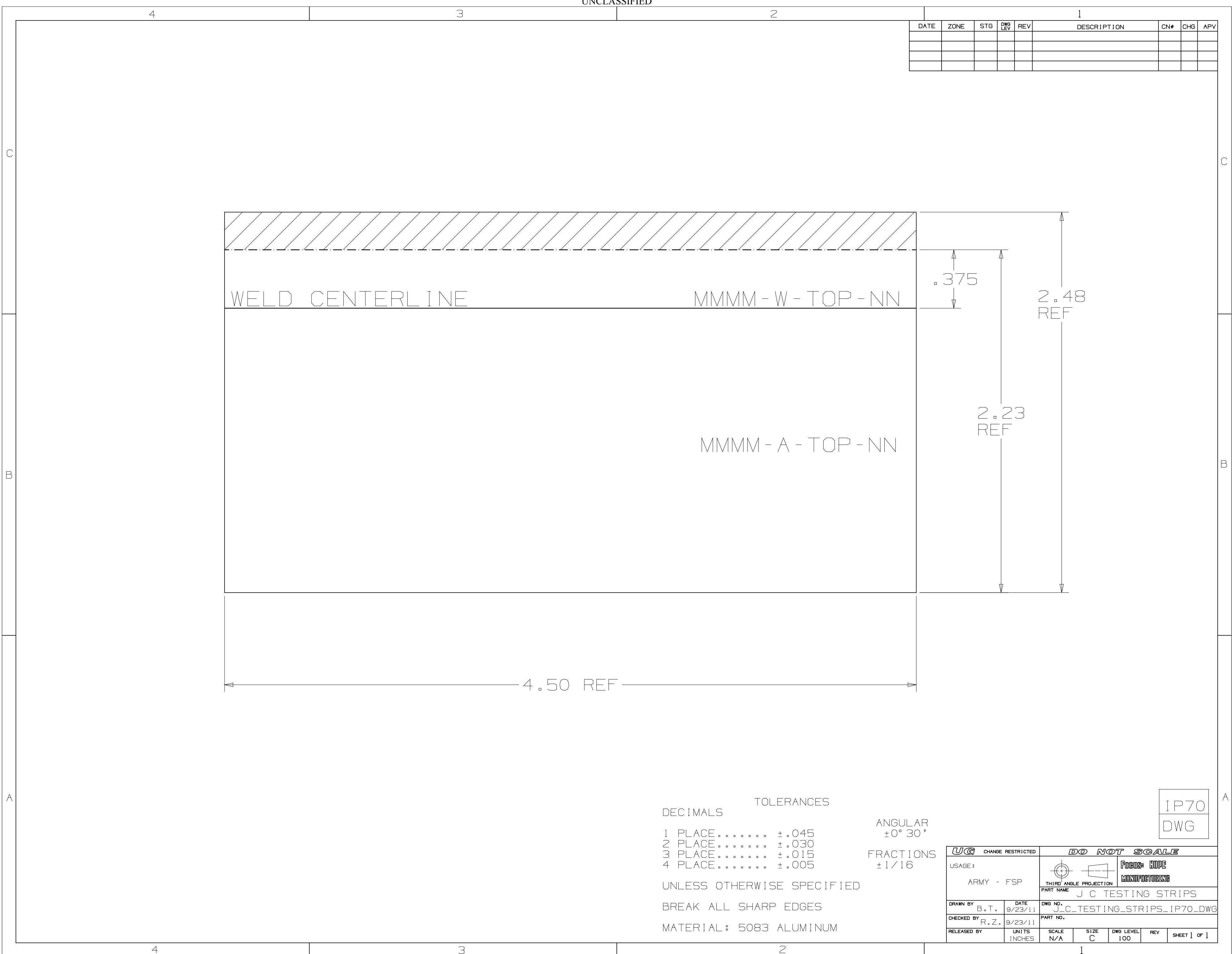
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3

2

1

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
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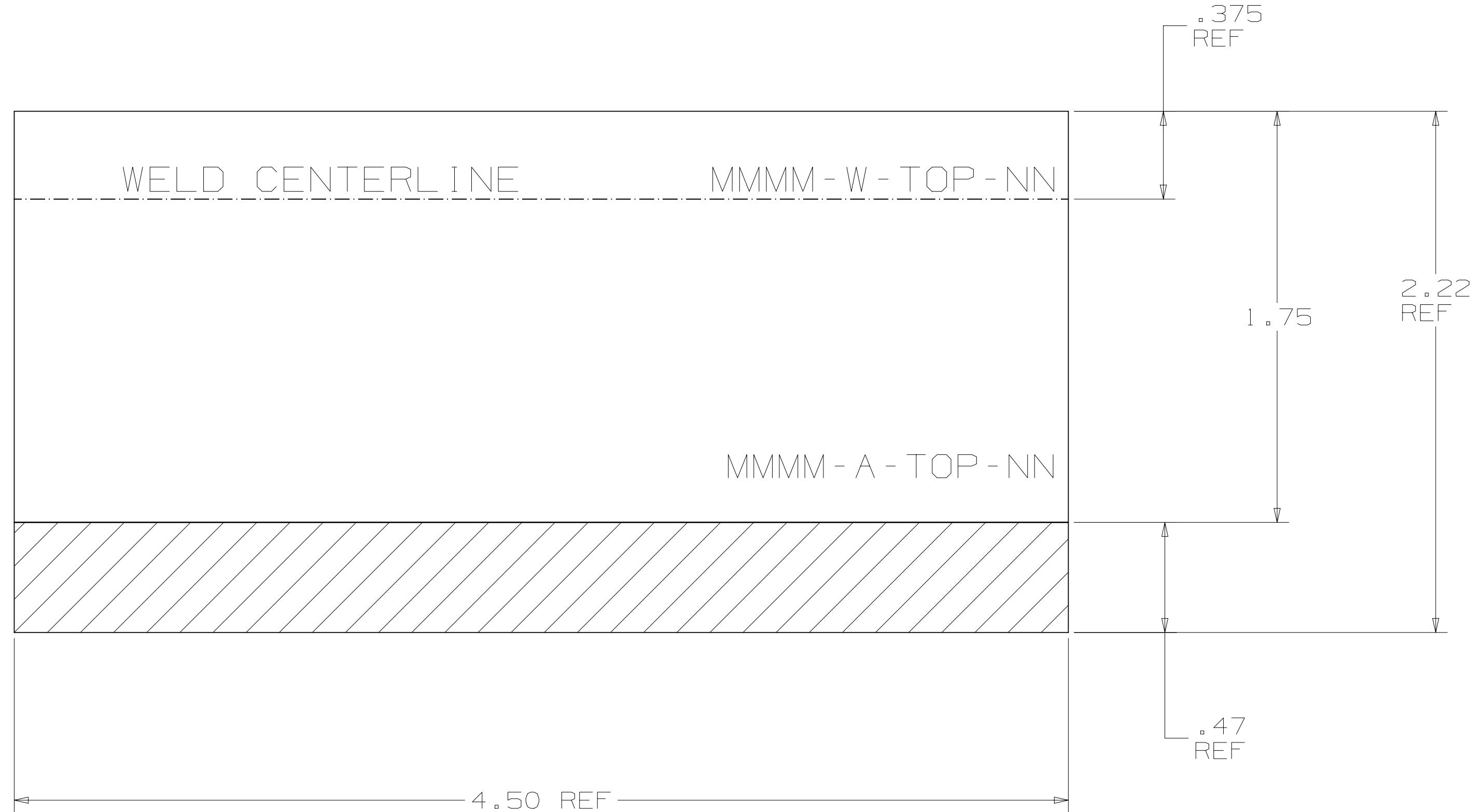
3

2

1

UNCLASSIFIED

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
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| | | | | | | | | |



TOLERANCES

DECIMALS

- 1 PLACE ± .045
 2 PLACE ± .030
 3 PLACE ± .015
 4 PLACE ± .005

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 5083 ALUMINUM

ANGULAR
±0° 30'FRACTIONS
±1/16

| | | | |
|-----------------------------|--------------|-------------------------------------|--------------|
| WG CHANGE RESTRICTED | | DO NOT SCALE | |
| USAGE: ARMY - FSP | | FOCUS: HOPE MANUFACTURING | |
| DRAWN BY B.T. 9/23/11 | | DWG NO. J_C TESTING STRIP | |
| CHECKED BY R.Z. 9/23/11 | | PART NO. J_C TESTING STRIP_IP80_DWG | |
| RELEASED BY | UNITS INCHES | SCALE N/A | SIZE C |
| | | DWG LEVEL 100 | REV |
| | | | SHEET 1 OF 1 |

IP80
DWG

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
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TOLERANCES

DECIMALS

- 1 PLACE $\pm .045$
 2 PLACE $\pm .030$
 3 PLACE $\pm .015$
 4 PLACE $\pm .005$

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 5083 ALUMINUM

ANGULAR
 $\pm 0^\circ 30'$ FRACTIONS
 $\pm 1/16$ IP90
DWG

| | | | |
|-----------------------------|--|-------------------------------------|---------------|
| WG CHANGE RESTRICTED | | DO NOT SCALE | |
| USAGE: | | FOCUS: HOPE MANUFACTURING | |
| ARMY - FSP | | THIRD ANGLE PROJECTION | |
| DRAWN BY B.T. 9/23/11 | | DWG NO. J_C TESTING STRIPS_IP90_DWG | |
| CHECKED BY R.Z. 9/23/11 | | PART NO. | |
| RELEASED BY | | UNITS INCHES | SCALE N/A |
| | | SIZE C | DWG LEVEL 100 |
| | | REV | SHEET 1 OF 1 |

UNCLASSIFIED

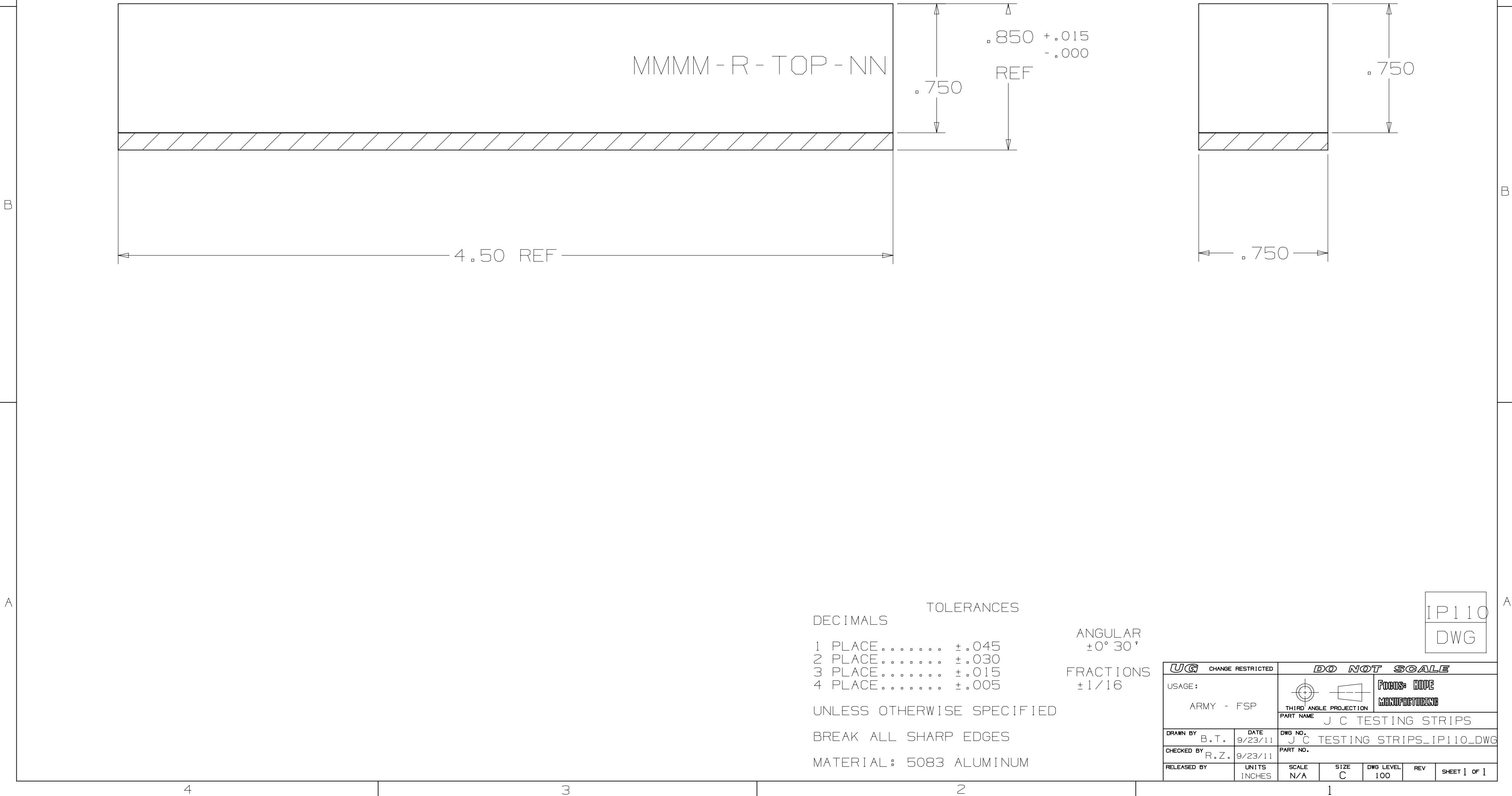
4

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2

1

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
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4

3

2

1

UNCLASSIFIED

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
| | | | | | | | | |
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TOLERANCES

DECIMALS

- 1 PLACE ± .045
 2 PLACE ± .030
 3 PLACE ± .015
 4 PLACE ± .005

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 5083 ALUMINUM

ANGULAR
± 0° 30'FRACTIONS
± 1/16

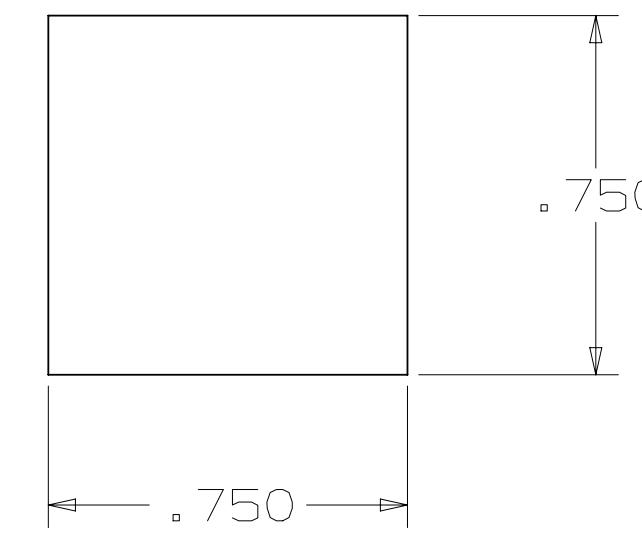
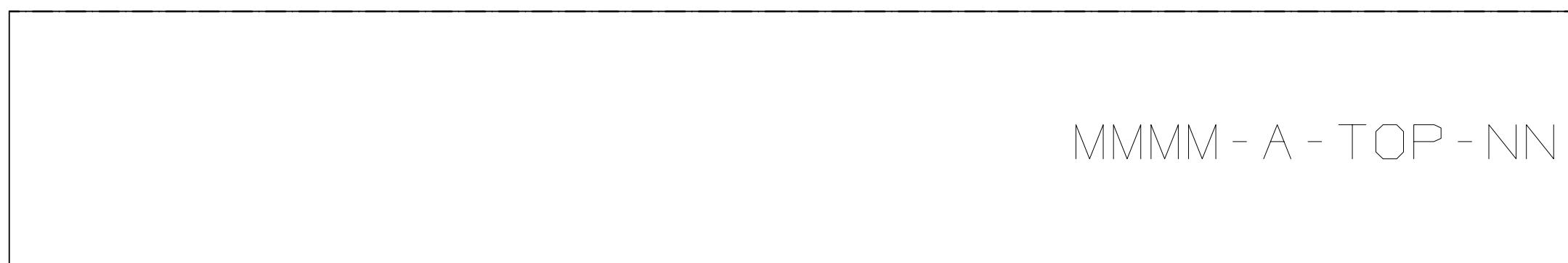
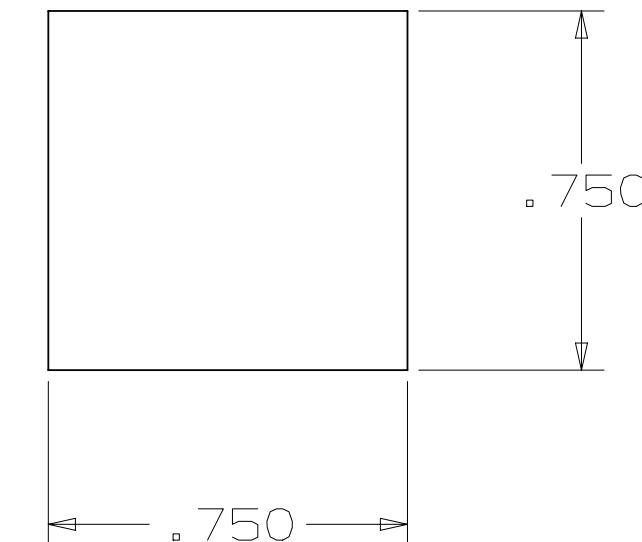
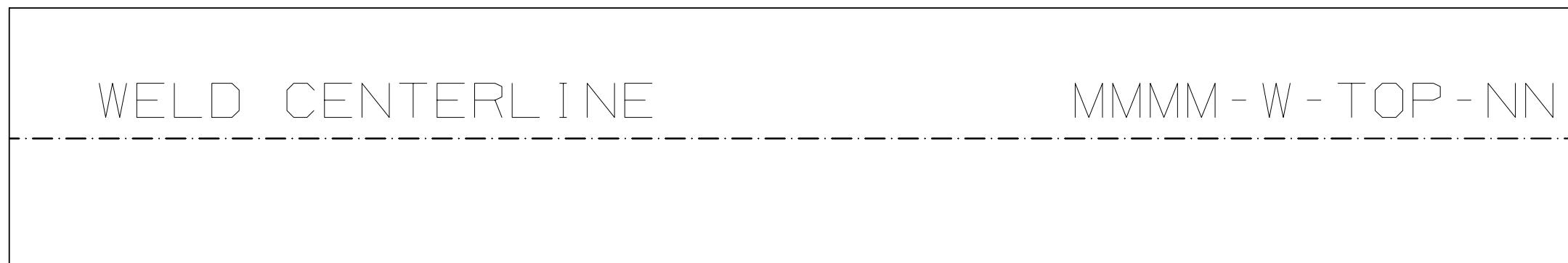
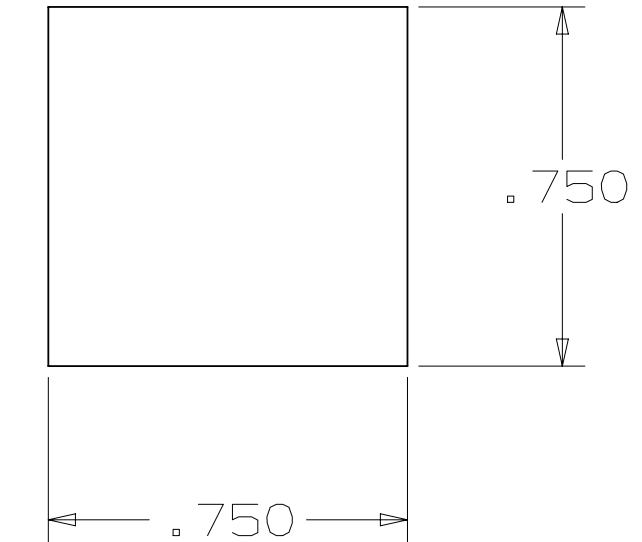
| | | | |
|-----------------------------|------|------------------------------|------------------|
| WG CHANGE RESTRICTED | | DO NOT SCALE | |
| USAGE: | | FOCUS: HOPE MANUFACTURING | |
| ARMY - FSP | | THIRD ANGLE PROJECTION | |
| DRAWN BY | B.T. | DATE | DWG NO. |
| CHECKED BY | | R.Z. | 9/23/11 |
| RELEASED BY | | UNITS INCHES | SCALE N/A |
| | | SIZE C | DWG LEVEL 100 |
| | | REV | SHEET 1 OF 1 |

J C TESTING STRIPS
 J_C_TESTING_STRIPS_IP120_DWG

IP120
DWG

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

TOP VIEW OF 3 FINISHED BLOCKS



TOLERANCES

DECIMALS

1 PLACE $\pm .045$
 2 PLACE $\pm .030$
 3 PLACE $\pm .015$
 4 PLACE $\pm .005$

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 5083 ALUMINUM

ANGULAR
 $\pm 0^\circ 30'$ FRACTIONS
 $\pm 1/16$

| | | |
|-------------------------|-------------------|--------------------------------------|
| WG | CHANGE RESTRICTED | DO NOT SCALE |
| USAGE: | | FOCUS: HOPE MANUFACTURING |
| ARMY - FSP | | THIRD ANGLE PROJECTION |
| DRAWN BY B.T. 9/23/11 | | DWG NO. J_C TESTING STRIPS_IP130.DWG |
| CHECKED BY R.Z. 9/23/11 | | PART NO. |
| RELEASED BY | UNITS INCHES | SCALE N/A |
| | | SIZE C |
| | | DWG LEVEL 100 |
| | | REV |
| | | SHEET 1 OF 1 |

UNCLASSIFIED

Focus: HOPE Process routing/Shop travelerCustomer: **Southwest Research Institute**

Street Address:

City State Zip:

Stock: **4 x 4.850 x .950 coupon (54)**Part Number: **Strips**Description: **Johnson-Cook test specimen blocks (2139)**

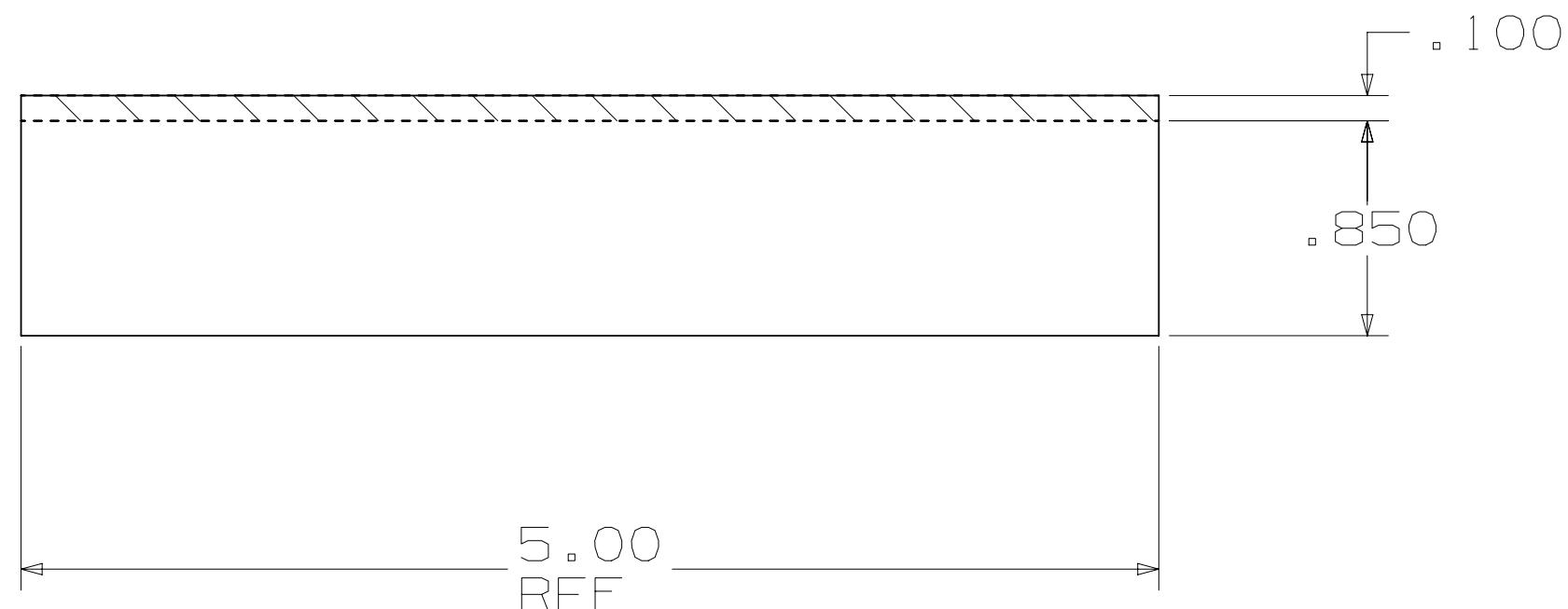
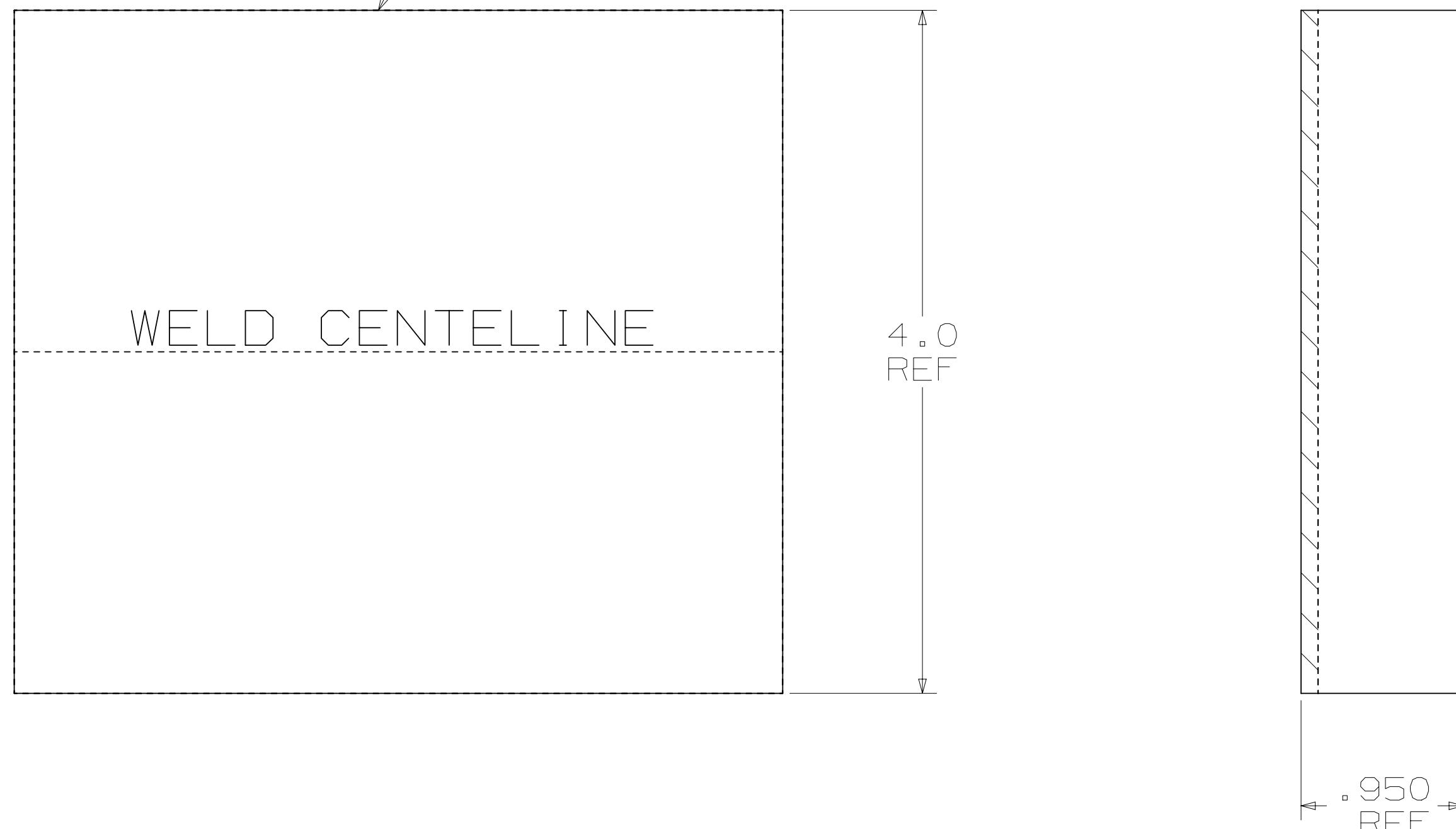
Revision:

| Op No | Labor Code | Operation Description |
|-------|----------------------|---|
| 10 | Mill | Mill TOP to 0.850 |
| 20 | Height Gage & Scribe | Find, and scribe weld centerlines on Top and Ends of block. |
| 30 | Laser Marker | Mark TOP face of coupon per print (MMMM-X-TOP-NN, Where X=A,W, or R) |
| 40 | Mill | Mill BOTTOM to 0.800 thick |
| 50 | Mill | Mill coupon to 1.2456 from weld centerline (retreating side) |
| 60 | Band Saw | Saw Block R(retreating side) to .675 SET ASIDE |
| 70 | Mill | Mill coupon to .400 from weld centerline (retreating side) |
| 80 | Mill | Flip around (TOP still facing up) and mill coupon to 1.6456 |
| 90 | Band Saw | Saw block at 'A' to .675 and remaining strip 'W' at .9706 ref |
| 100 | Mill | Mill 'W' to .800 (from saw cut side) |
| 110 | Mill | Mill R to .625 (From saw cut side) |
| 120 | Mill | Mill A to .625 (from saw cut side) |
| 130 | Mill | Mill block 'R' BOTTOM .1375 REF to 0.6535 |
| 140 | Mill | Mill block 'R' TOP .0285 REF to 0.625 |
| 150 | Mill | Mill block 'A' BOTTOM .1375 REF to 0.6535 |
| 160 | Mill | Mill block 'A' TOP .0285 REF to 0.625 |
| 170 | | Measurement of finished blocks, per inspection check sheet |

UNCLASSIFIED

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
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RETREATING SIDE
(CLAMP MARKS)

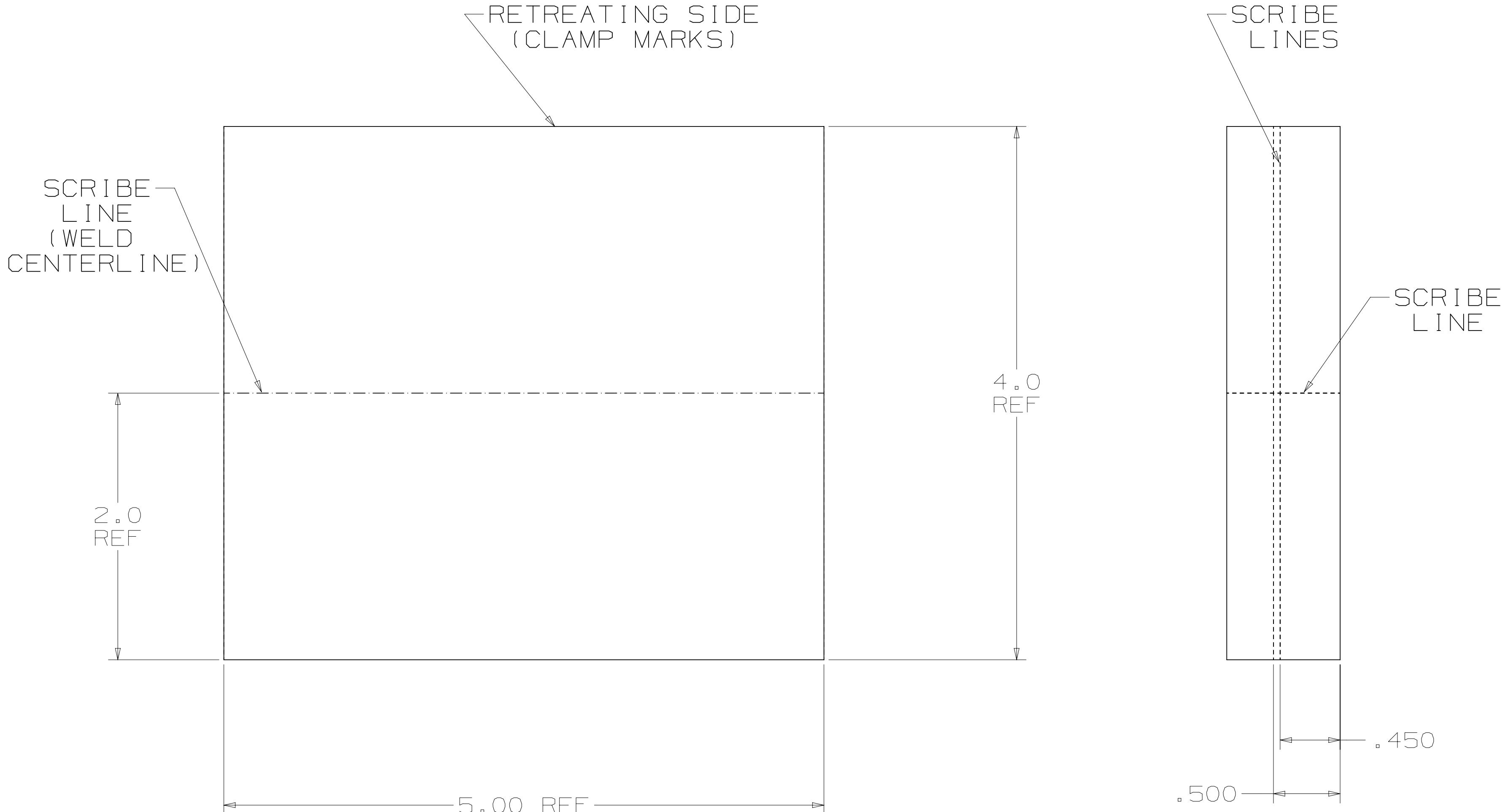


| TOLERANCES | | ANGULAR |
|--------------|---------|-----------|
| DECIMALS | | |
| 1 PLACE..... | ± .030 | ± 0° 30' |
| 2 PLACE..... | ± .010 | |
| 3 PLACE..... | ± .005 | FRACTIONS |
| 4 PLACE..... | ± .0005 | ± 1/64 |

UNLESS OTHERWISE SPECIFIED
BREAK ALL SHARP EDGES
MATERIAL: 2139 AL

IP10
DWG

| CHANGE RESTRICTED | | DO NOT SCALE | |
|-------------------|----------|------------------------------|---------------------------------|
| USAGE: | ARMY-FSP | FOCUS: HOPE MANUFACTURING | THIRD ANGLE PROJECTION |
| DRAWN BY | B.T. | DATE | DWG NO: JLC TESTING STRIPS_IP10 |
| CHECKED BY | R.Z. | 11/22/11 | PART NO. X |
| RELEASED BY | | UNITS INCHES | SCALE N/A |
| | | SIZE C | DWG LEVEL 100 |
| | | REV | SHEET 1 OF 1 |



TOLERANCES
DECIMALS

1 PLACE ± .030
2 PLACE ± .010
3 PLACE ± .005
4 PLACE ± .0005

ANGULAR
± 0° 30'

FRACTIONS
± 1/16

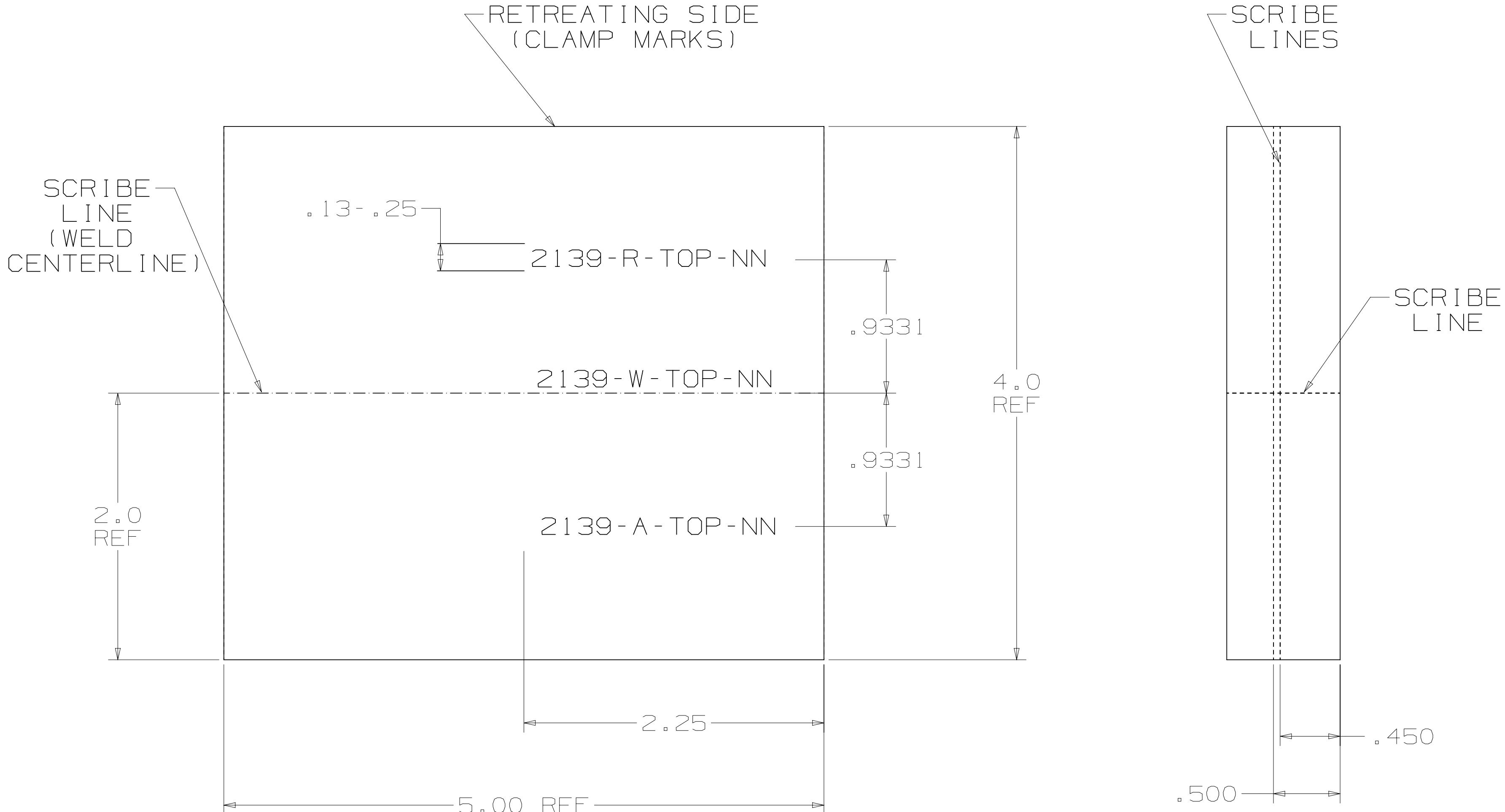
UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP20
DWG

| CHANGE RESTRICTED | DO NOT SCALE | FOCUS: HOPE MANUFACTURING |
|-------------------------------|--------------|-------------------------------------|
| ARMY - FSP | | THIRD ANGLE PROJECTION |
| DRAWN BY B.T. DATE 11/29/11 | | DWG NO. J_C TESTING STRIPS_IP20_DWG |
| CHECKED BY R.Z. DATE 11/29/11 | PART NO. | |
| RELEASED BY | UNITS INCHES | SCALE N/A |
| | | SIZE C |
| | | DWG LEVEL 100 |
| | | REV SHEET 1 OF 1 |



TOLERANCES
DECIMALS

1 PLACE ± .030
2 PLACE ± .010
3 PLACE ± .005
4 PLACE ± .0005

ANGULAR
± 0° 30'

FRACTIONS
± 1/16

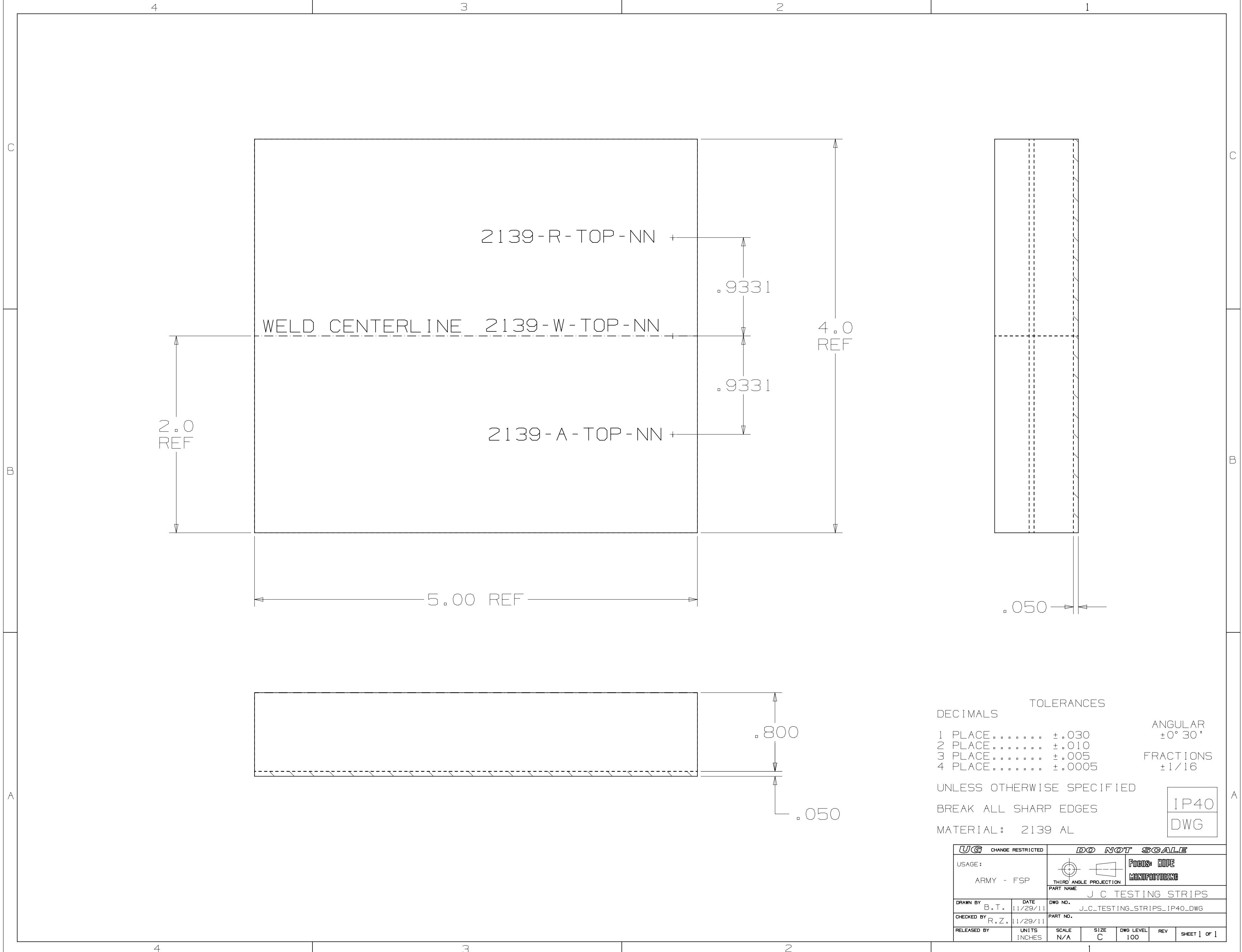
UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

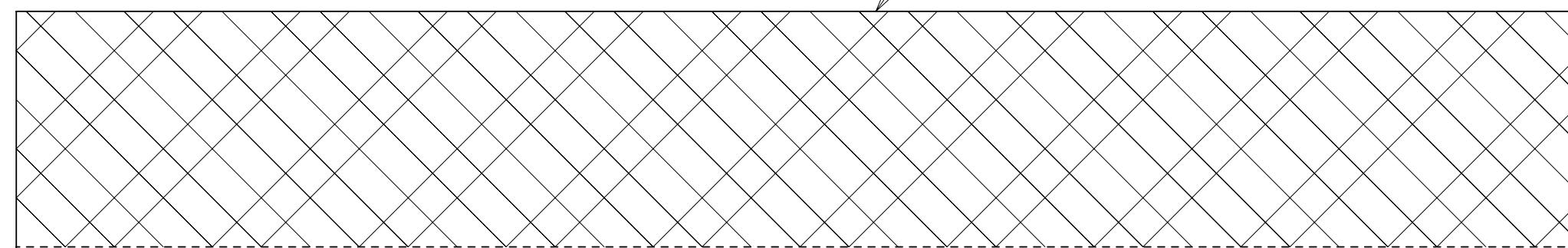
MATERIAL: 2139 AL

IP30
DWG

| CHANGE RESTRICTED | DO NOT SCALE |
|------------------------|---------------------------|
| USAGE: | FOCUS: HOPE MANUFACTURING |
| THIRD ANGLE PROJECTION | |
| PART NAME | J C TESTING STRIPS |
| DRAWN BY | B.T. |
| DATE | 11/29/11 |
| CHECKED BY | R.Z. |
| DATE | 11/29/11 |
| RELEASED BY | |
| UNITS | INCHES |
| SCALE | N/A |
| SIZE | C |
| DWG LEVEL | 100 |
| REV | |
| SHEET | 1 OF 1 |



CLAMP MARKS

.7544
REF

1.2456

4.0
REF3.2456
REF

WELD CENTERLINE

2139-W-TOP-NN

2139-A-TOP-NN

5.00 REF

TOLERANCES

DECIMALS

- 1 PLACE $\pm .030$
 2 PLACE $\pm .010$
 3 PLACE $\pm .005$
 4 PLACE $\pm .0005$

ANGULAR
 $\pm 0^\circ 30'$ FRACTIONS
 $\pm 1/16$

UNLESS OTHERWISE SPECIFIED

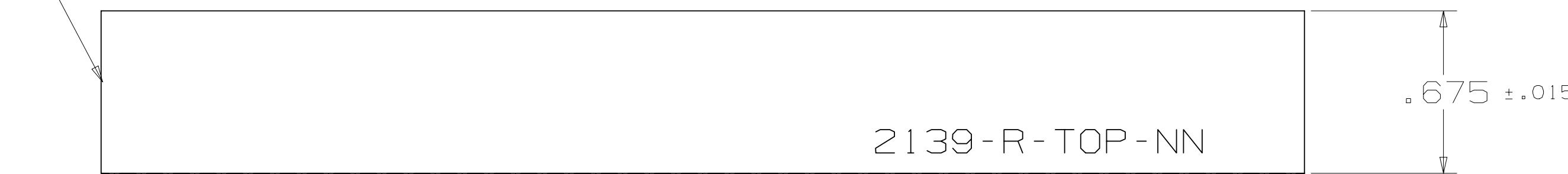
BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP50
DWG

| CHANGE RESTRICTED | | DO NOT SCALE | |
|-------------------|------|---------------------------|-----------------------------|
| USAGE: | | FOCUS: HOPE MANUFACTURING | |
| ARMY - FSP | | THIRD ANGLE PROJECTION | |
| DRAWN BY | B.T. | DATE | DWG NO. |
| CHECKED BY | R.Z. | 11/29/11 | J_C TESTING STRIPS_IP50_DWG |
| RELEASED BY | | UNITS INCHES | PART NO. |
| | | SCALE N/A | REV |
| | | SIZE C | SHEET 1 OF 1 |
| | | DWG LEVEL 100 | |

RESULT OF CUTOFF



WELD CENTERLINE

2139-W-TOP-NN

2139-A-TOP-NN

.4456 ± .015

2.4456

5.00 REF

TOLERANCES

DECIMALS

- 1 PLACE ± .030
 2 PLACE ± .010
 3 PLACE ± .005
 4 PLACE ± .0005

ANGULAR
± 0° 30'FRACTIONS
± 1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP60
DWG

| CHANGE RESTRICTED | | DO NOT SCALE | |
|--------------------------|--------------|-------------------------------------|---------------|
| USAGE: | | FOCUS: HOPE MANUFACTURING | |
| DRAWN BY B.T. 11/29/11 | | DWG NO. J_C TESTING STRIPS_IP60_DWG | |
| CHECKED BY R.Z. 11/29/11 | | PART NO. | |
| RELEASED BY | UNITS INCHES | SCALE N/A | SIZE C |
| | | | DWG LEVEL 100 |
| | | REV | SHEET 1 OF 1 |



TOLERANCES

DECIMALS

- 1 PLACE $\pm .030$
 2 PLACE $\pm .010$
 3 PLACE $\pm .005$
 4 PLACE $\pm .0005$

ANGULAR
 $\pm 0^\circ 30'$

FRACTIONS
 $\pm 1/16$

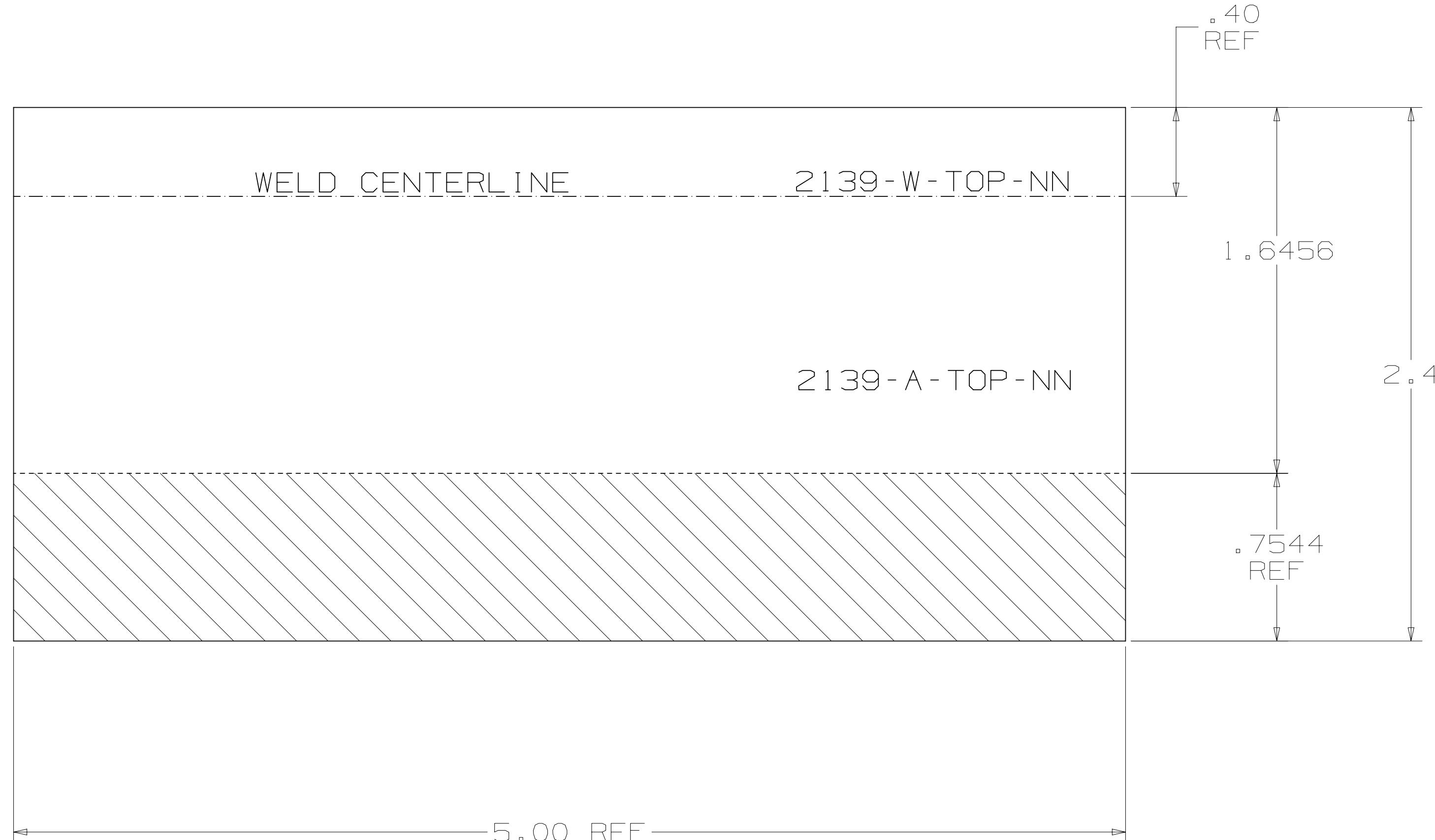
UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP70
DWG

| CHANGE RESTRICTED | | DO NOT SCALE | |
|-------------------|------|---------------------------|-----------------------------|
| USAGE: | | FOCUS: HOPE MANUFACTURING | |
| ARMY - FSP | | THIRD ANGLE PROJECTION | |
| DRAWN BY | B.T. | DATE | DWG NO. |
| CHECKED BY | R.Z. | 11/29/11 | J_C TESTING STRIPS_IP70_DWG |
| RELEASED BY | | UNITS INCHES | PART NO. |
| | | N/A | REV |
| | | C | SHEET 1 OF 1 |
| | | 100 | |



TOLERANCES

DECIMALS

1 PLACE $\pm .030$
 2 PLACE $\pm .010$
 3 PLACE $\pm .005$
 4 PLACE $\pm .0005$

ANGULAR
 $\pm 0^\circ 30'$

FRACTIONS
 $\pm 1/16$

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP80
DWG

| WG CHANGE RESTRICTED | | DO NOT SCALE | |
|----------------------|------|---------------------------|-----------------------------|
| USAGE: | | FOCUS: HOPE MANUFACTURING | |
| ARMY - FSP | | THIRD ANGLE PROJECTION | |
| DRAWN BY | B.T. | DATE | DWG NO. |
| CHECKED BY | R.Z. | 11/29/11 | J_C TESTING STRIPS_IP80_DWG |
| RELEASED BY | | UNITS INCHES | PART NO. |
| | | SCALE N/A | SIZE C |
| | | REV 100 | DWG LEVEL 100 |
| | | SHEET 1 OF 1 | |

WELD CENTERLINE

2139-W-TOP-NN

.8456
REF
.4456

RESULT OF CUTOFF

2139-A-TOP-NN

.675 $^{+.015}_{-.000}$

5.00 REF

TOLERANCES

DECIMALS

- 1 PLACE $\pm .030$
 2 PLACE $\pm .010$
 3 PLACE $\pm .005$
 4 PLACE $\pm .0005$

ANGULAR
 $\pm 0^\circ 30'$
FRACTIONS
 $\pm 1/16$

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP90
DWG

| CHANGE RESTRICTED | | DO NOT SCALE | | FOCUS: HOPE MANUFACTURING | |
|-------------------|------|--------------|----------|-------------------------------|-----------------------------|
| USAGE: | | ARMY - FSP | | PART NAME: J_C TESTING STRIPS | |
| DRAWN BY | B.T. | DATE | 11/29/11 | DWG NO. | J_C_TESTING_STRIPS_IP90_DWG |
| CHECKED BY | R.Z. | DATE | 11/29/11 | PART NO. | |
| RELEASED BY | | UNITS | INCHES | SCALE | N/A |
| | | SIZE | C | DWG LEVEL | 100 |
| | | REV | | SHEET | 1 OF 1 |



TOLERANCES

DECIMALS

- 1 PLACE $\pm .030$
 2 PLACE $\pm .010$
 3 PLACE $\pm .005$
 4 PLACE $\pm .0005$

ANGULAR
 $\pm 0^\circ 30'$

FRACTIONS
 $\pm 1/16$

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP100
DWG

| WG | | CHANGE RESTRICTED | DO NOT SCALE | | | | | |
|--------------------------|--|--------------------------------------|--------------|-----------|------------------|---------------------|--|--|
| USAGE: | | FOCUS: HOPE MANUFACTURING | | | | | | |
| ARMY - FSP | | THIRD ANGLE PROJECTION | | | | | | |
| DRAWN BY B.T. 11/29/11 | | DWG NO. J_C TESTING STRIPS_IP100_DWG | | | | | | |
| CHECKED BY R.Z. 11/29/11 | | PART NO. | | | | | | |
| RELEASED BY | | UNITS INCHES | SCALE N/A | SIZE C | DWG LEVEL 100 | REV SHEET 1 OF 1 | | |



TOLERANCES

DECIMALS

- 1 PLACE $\pm .030$
 2 PLACE $\pm .010$
 3 PLACE $\pm .005$
 4 PLACE $\pm .0005$

ANGULAR
 $\pm 0^\circ 30'$

FRACTIONS
 $\pm 1/16$

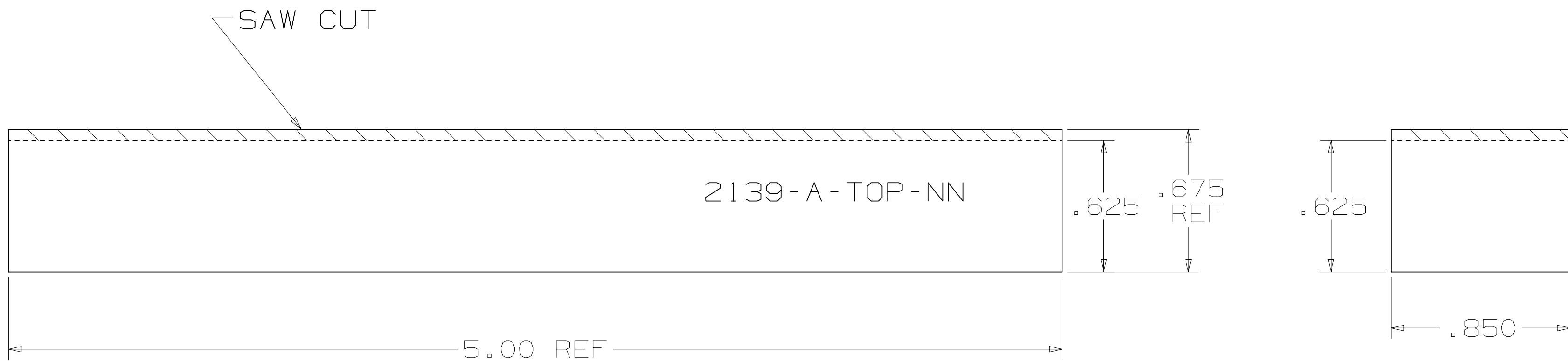
UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP110
DWG

| CHANGE RESTRICTED | | DO NOT SCALE | |
|-------------------|------|------------------------------|------------------------|
| USAGE: | | FOCUS: HOPE MANUFACTURING | |
| DRAWN BY | | DATE | |
| B.T. | | 11/29/11 | J_C TESTING STRIPS_DWG |
| CHECKED BY | R.Z. | 11/29/11 | PART NO. |
| RELEASED BY | | UNITS INCHES | SCALE N/A |
| | | SIZE C | DWG LEVEL 100 |
| | | REV | SHEET 1 OF 1 |



TOLERANCES

DECIMALS

- 1 PLACE $\pm .030$
 2 PLACE $\pm .010$
 3 PLACE $\pm .005$
 4 PLACE $\pm .0005$

ANGULAR
 $\pm 0^\circ 30'$
 FRACTIONS
 $\pm 1/16$

UNLESS OTHERWISE SPECIFIED

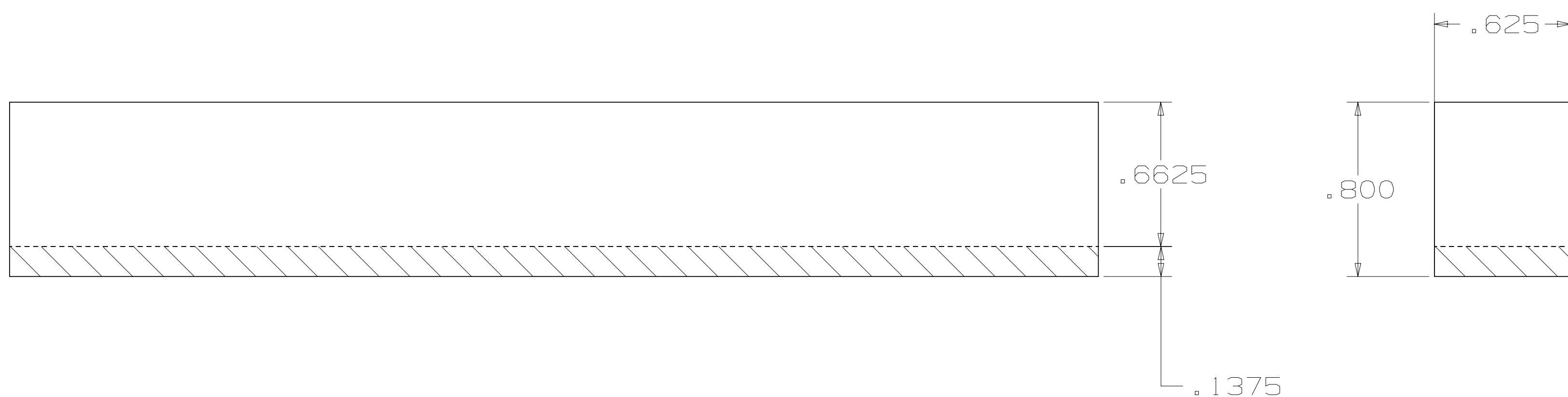
BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP120
DWG

| CHANGE RESTRICTED | | DO NOT SCALE | |
|--------------------------|--------------|--------------------------------------|--------------------------------|
| USAGE: | | FOCUS: HOPE MANUFACTURING | |
| DRAWN BY B.T. 11/29/11 | | DWG NO. J_C TESTING STRIPS_IP120_DWG | |
| CHECKED BY R.Z. 11/29/11 | | PART NO. | |
| RELEASED BY | UNITS INCHES | SCALE N/A | SIZE C |
| | | | DWG LEVEL 100 REV SHEET 1 OF 1 |

2139-R-TOP-NN



TOLERANCES

DECIMALS

- 1 PLACE $\pm .030$
 2 PLACE $\pm .010$
 3 PLACE $\pm .005$
 4 PLACE $\pm .0005$

ANGULAR
 $\pm 0^\circ 30'$

FRACTIONS
 $\pm 1/16$

UNLESS OTHERWISE SPECIFIED

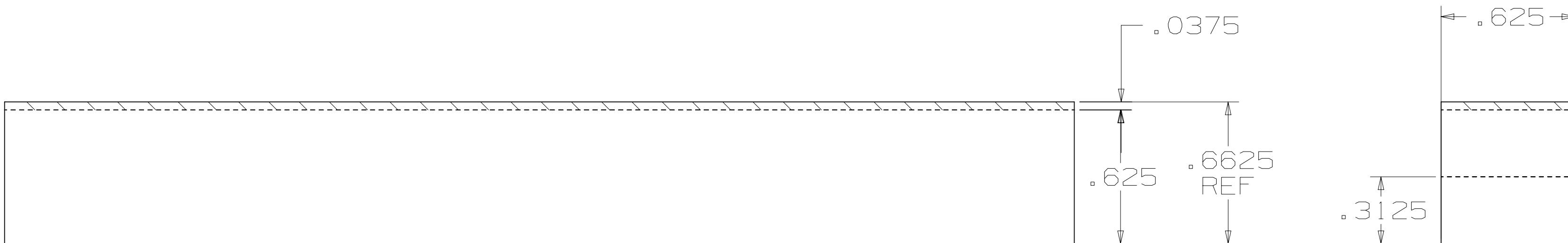
BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP130
DWG

| WG CHANGE RESTRICTED | | DO NOT SCALE | | FOCUS: HOPE MANUFACTURING | |
|----------------------|------|------------------------|----------|------------------------------|------------------------------|
| USAGE: | | THIRD ANGLE PROJECTION | | PART NAME: JC TESTING STRIPS | |
| DRAWN BY | B.T. | DATE | 11/29/11 | DWG NO. | J_C_TESTING_STRIPS_IP130_DWG |
| CHECKED BY | R.Z. | DATE | 11/29/11 | PART NO. | |
| RELEASED BY | | UNITS | INCHES | SCALE | N/A |
| | | SIZE | C | DWG LEVEL | 100 |
| | | REV | | SHEET | 1 OF 1 |

2139-R-TOP-NN



TOLERANCES

DECIMALS

- 1 PLACE $\pm .030$
 2 PLACE $\pm .010$
 3 PLACE $\pm .005$
 4 PLACE $\pm .0005$

ANGULAR
 $\pm 0^\circ 30'$

FRACTIONS
 $\pm 1/16$

UNLESS OTHERWISE SPECIFIED

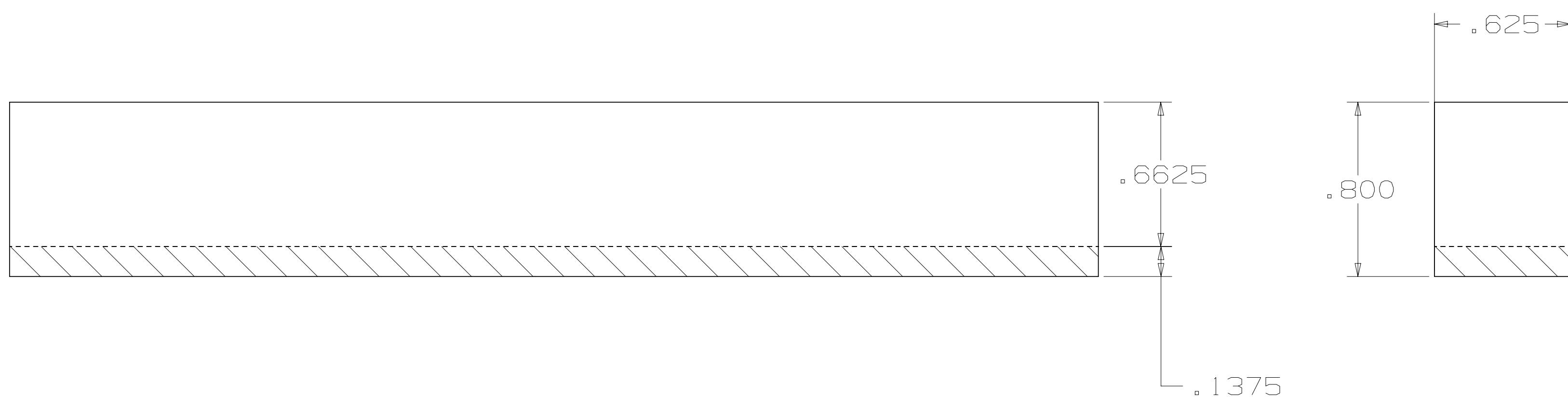
BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP140
DWG

| UG CHANGE RESTRICTED | | DO NOT SCALE | |
|----------------------|------|---------------------------|------------------------------|
| USAGE: | | FOCUS: HOPE MANUFACTURING | |
| ARMY - FSP | | THIRD ANGLE PROJECTION | |
| DRAWN BY | B.T. | DATE | DWG NO. |
| CHECKED BY | R.Z. | 11/29/11 | J_C TESTING STRIPS_IP140_DWG |
| RELEASED BY | | UNITS INCHES | PART NO. |
| | | N/A | REV |
| | | C | SHEET 1 OF 1 |
| | | 100 | |

2139-A-TOP-NN



TOLERANCES

DECIMALS

- 1 PLACE $\pm .030$
 2 PLACE $\pm .010$
 3 PLACE $\pm .005$
 4 PLACE $\pm .0005$

ANGULAR
 $\pm 0^\circ 30'$

FRACTIONS
 $\pm 1/16$

UNLESS OTHERWISE SPECIFIED

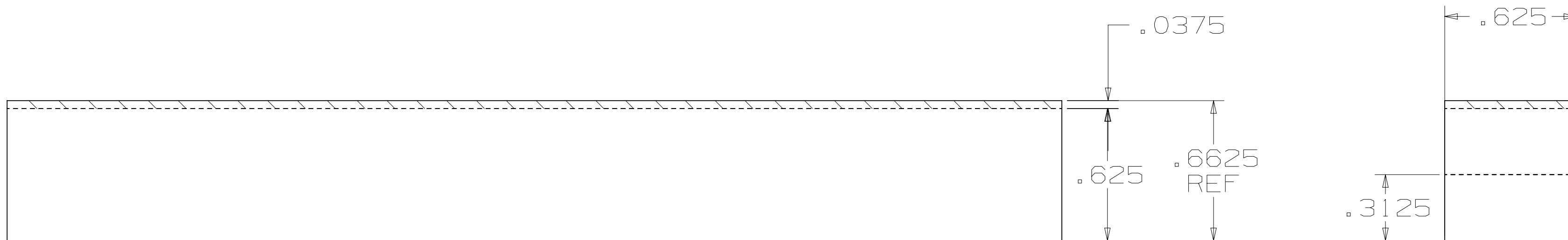
BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP150
DWG

| WG CHANGE RESTRICTED | | DO NOT SCALE | | FOCUS: HOPE MANUFACTURING | |
|----------------------|------|--------------|----------|------------------------------|------------------------------|
| USAGE: | | ARMY - FSP | | PART NAME: JC TESTING STRIPS | |
| DRAWN BY | B.T. | DATE | 11/29/11 | DWG NO. | J_C_TESTING_STRIPS_IP150_DWG |
| CHECKED BY | R.Z. | DATE | 11/29/11 | PART NO. | |
| RELEASED BY | | UNITS | INCHES | SCALE | N/A |
| | | | | SIZE | C |
| | | | | DWG LEVEL | 100 |
| | | | | REV | |
| | | | | SHEET | 1 OF 1 |

2139-A-TOP-NN



TOLERANCES

DECIMALS

- 1 PLACE $\pm .030$
 2 PLACE $\pm .010$
 3 PLACE $\pm .005$
 4 PLACE $\pm .0005$

ANGULAR
 $\pm 0^\circ 30'$ FRACTIONS
 $\pm 1/16$

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

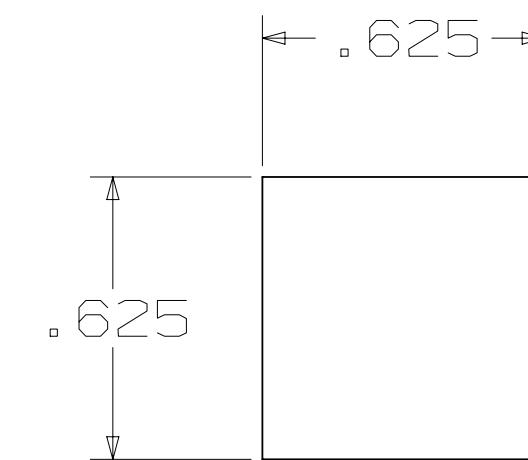
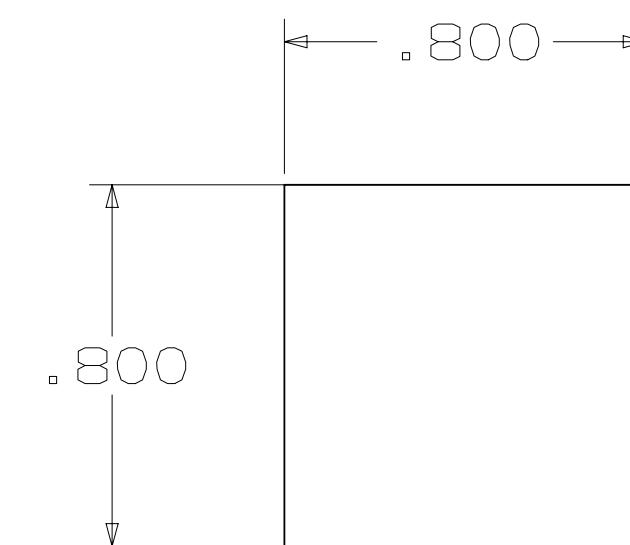
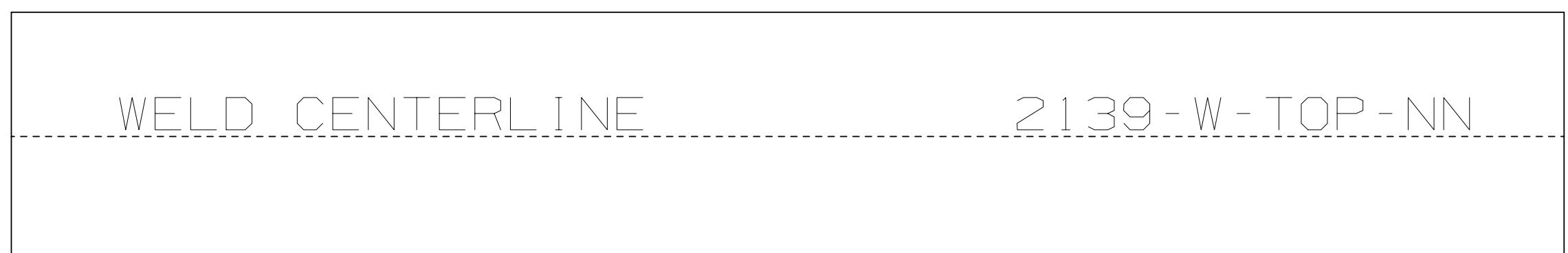
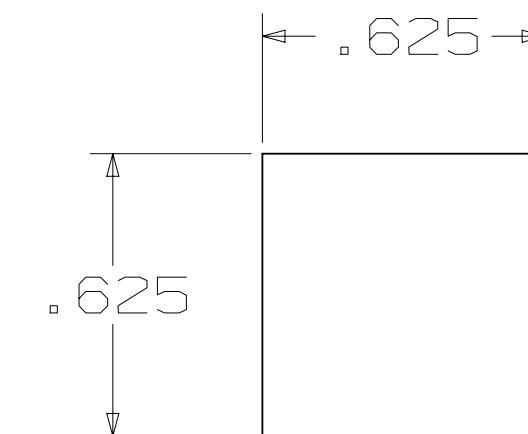
MATERIAL: 2139 AL

IP160
DWG

| UG CHANGE RESTRICTED | | DO NOT SCALE | |
|----------------------|------|---------------------------|------------------------------|
| USAGE: | | FOCUS: HOPE MANUFACTURING | |
| ARMY - FSP | | THIRD ANGLE PROJECTION | |
| DRAWN BY | B.T. | DATE | DWG NO. |
| CHECKED BY | R.Z. | 11/29/11 | J_C TESTING STRIPS_IP160_DWG |
| RELEASED BY | | UNITS INCHES | PART NO. |
| | | N/A | REV |
| | | C | SHEET 1 OF 1 |
| | | 100 | |

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

TOP VIEW OF 3 FINISHED BLOCKS

TOLERANCES
DECIMALS

| | |
|---------------|-------------|
| 1 PLACE | $\pm .030$ |
| 2 PLACE | $\pm .010$ |
| 3 PLACE | $\pm .005$ |
| 4 PLACE | $\pm .0005$ |

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

ANGULAR

 $\pm 0^\circ 30'$

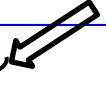
FRACTIONS

 $\pm 1/64$

| | |
|-------------------------------|---------------|
| CHANGE RESTRICTED | DO NOT SCALE |
| FOCUS: HOPE MANUFACTURING | |
| PART NAME: J C TESTING STRIPS | |
| DRAWN BY | DATE |
| B. T. | 11/29/11 |
| CHECKED BY | DATE |
| R. Z. | 11/29/11 |
| RELEASED BY | UNITS |
| | INCHES |
| | SCALE N/A |
| | SIZE C |
| | DWG LEVEL 100 |
| | REV X |
| | SHEET 1 OF 1 |

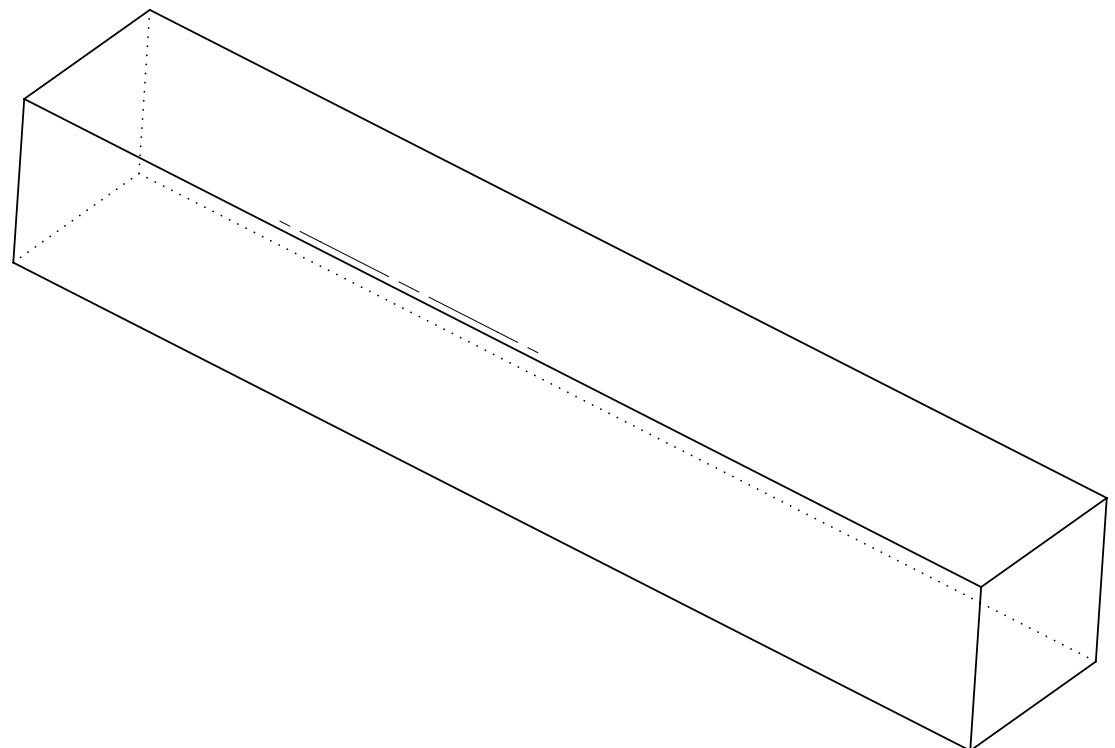
UNCLASSIFIED

Focus: HOPE Process routing/Shop traveler

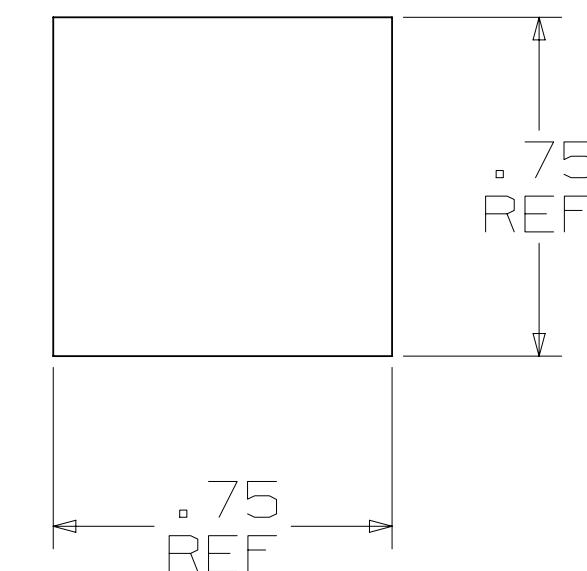
| Customer: Southwest Research Institute Street Address: City State Zip: Stock: 3/4" x 3/4" x 4 1/2" FSW weld coupon (4 RET) | | |
|---|------------|--|
| Part Number: TAIT specimen Description: Johnson-Cook test specimens Revision: | | |
| | | |
| | | |
| Op No | Labor Code | Operation Description |
| | | See 'Strips' Process Sheet for initial specimen extraction operations. |
| | | <i>Extreme care must be taken to keep Specimen Types R, W, and A, and Materials 6061 and 5083 properly segregated. THIS IS EXTREMELY IMPORTANT,</i> |
| 10 | | Confirm that all specimens are "6061-A"  |
| 20 | MILL | Circular interpolate end to .70 dia x .88 |
| 30 | CNC | Center Drill, Turn square end round to .252/.254 x 1.5, .625 x 1.3; cut-off at 1.375 |
| 40 | | Retrieve and label specimen |
| | | <i>DO NOT mark the final part in any way (laser, paint, etc.)</i> |
| | | Individually bag each part and mark each bag "61A-N-#-N" for Block Number and # for specimen  |
| 50 | CNC | rechuck part against shoulder; turn to .252/.254 dia. x 1.5 |
| 60 | CNC | Turn to .252/.254 dia. x 1.5; cut-off at 1.375 |
| 70 | | Retrieve and label specimens |
| 80 | MILL | Face mill each specimen to 1.3 |
| 90 | MILL | Flip part and face mill 1.250 |
| 100 | | Bag and Label |
| | | |

UNCLASSIFIED

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
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| | | | | | | | | |



MMMM-X-TOP-NN

4.50
REF

TOLERANCES

DECIMALS

| | |
|---------------|---------|
| 1 PLACE | ± .030 |
| 2 PLACE | ± .010 |
| 3 PLACE | ± .003 |
| 4 PLACE | ± .0005 |

| | |
|-----------|----------|
| ANGULAR | ± 0° 30' |
| FRACTIONS | ± 1/64 |

UNLESS OTHERWISE SPECIFIED

MATERIAL:

| | |
|-----------------------------|---------------|
| CHANGE RESTRICTED | DO NOT SCALE |
| USAGE: ARMY-FSP | |
| FOCUS: HOPE MANUFACTURING | |
| THIRD ANGLE PROJECTION | |
| PART NAME: T A I T SPECIMEN | |
| DRAWN BY: B.T. | DATE: 10/5/11 |
| CHECKED BY: R.Z. | DATE: 10/5/11 |
| RELEASED BY: | SCALE N/A |
| | SIZE C |
| | DWG LEVEL 100 |
| | REV |
| | SHEET 1 OF 1 |

IP10
DWG

UNCLASSIFIED

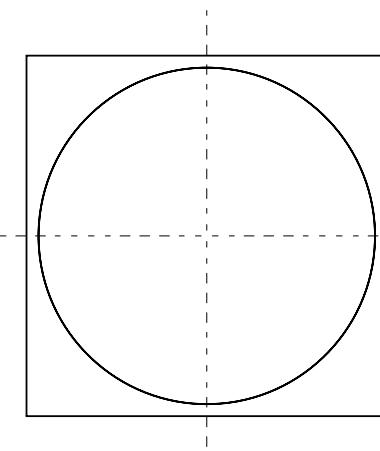
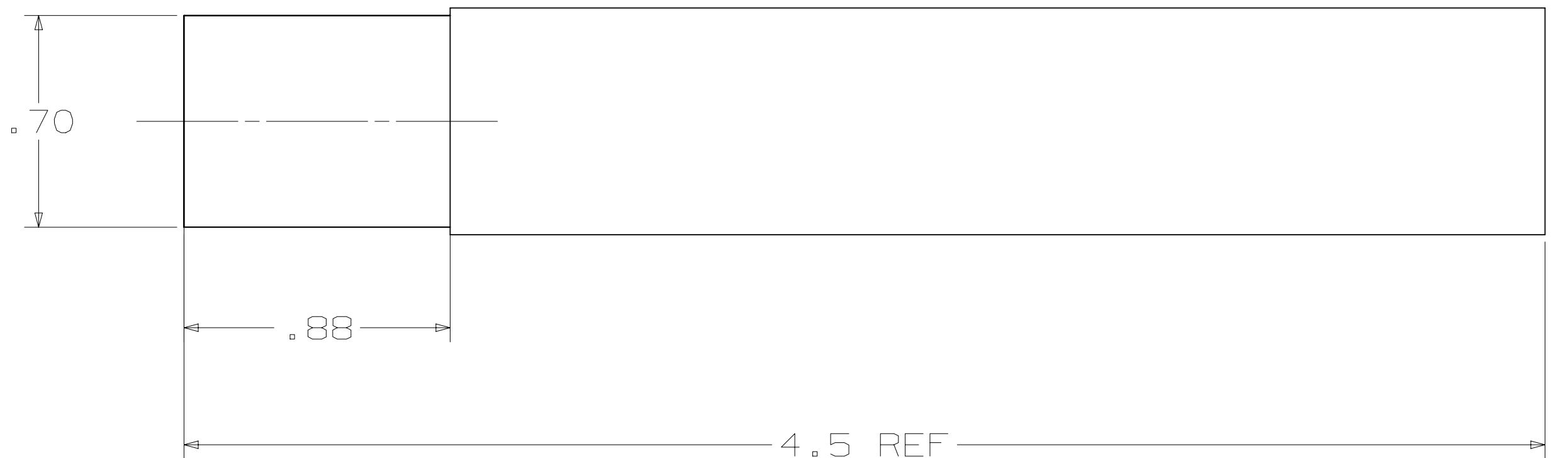
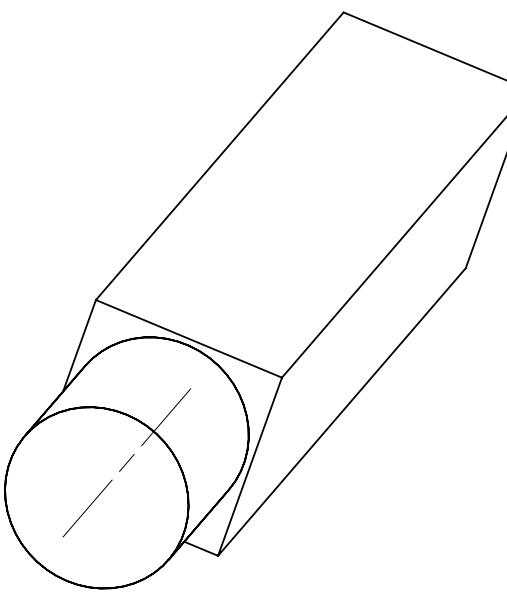
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3

2

1

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
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| | | | | | | | | |



TOLERANCES

DECIMALS

- 1 PLACE $\pm .030$
 2 PLACE $\pm .010$
 3 PLACE $\pm .003$
 4 PLACE $\pm .0005$

UNLESS OTHERWISE SPECIFIED

MATERIAL:

ANGULAR

 $\pm 0^\circ 30'$

FRACTIONS

 $\pm 1/64$ IP20
DWG

| | | |
|-----------------|-------------------|---------------------------------|
| WG | CHANGE RESTRICTED | D&O NOT SCALE |
| USAGE: | | FOCUS: HOPE MANUFACTURING |
| ARMY FSP | | THIRD ANGLE PROJECTION |
| | | PART NAME TAIT SPECIMEN |
| DRAWN BY B.T. | DATE 9/27/11 | DWG NO. T_AIT_SPECIMEN_IP20_DWG |
| CHECKED BY R.Z. | 9/27/11 | PART NO. |
| RELEASED BY | | SCALE N/A |
| | | SIZE C |
| | | DWG LEVEL 100 |
| | | REV |
| | | SHEET 1 OF 1 |

4

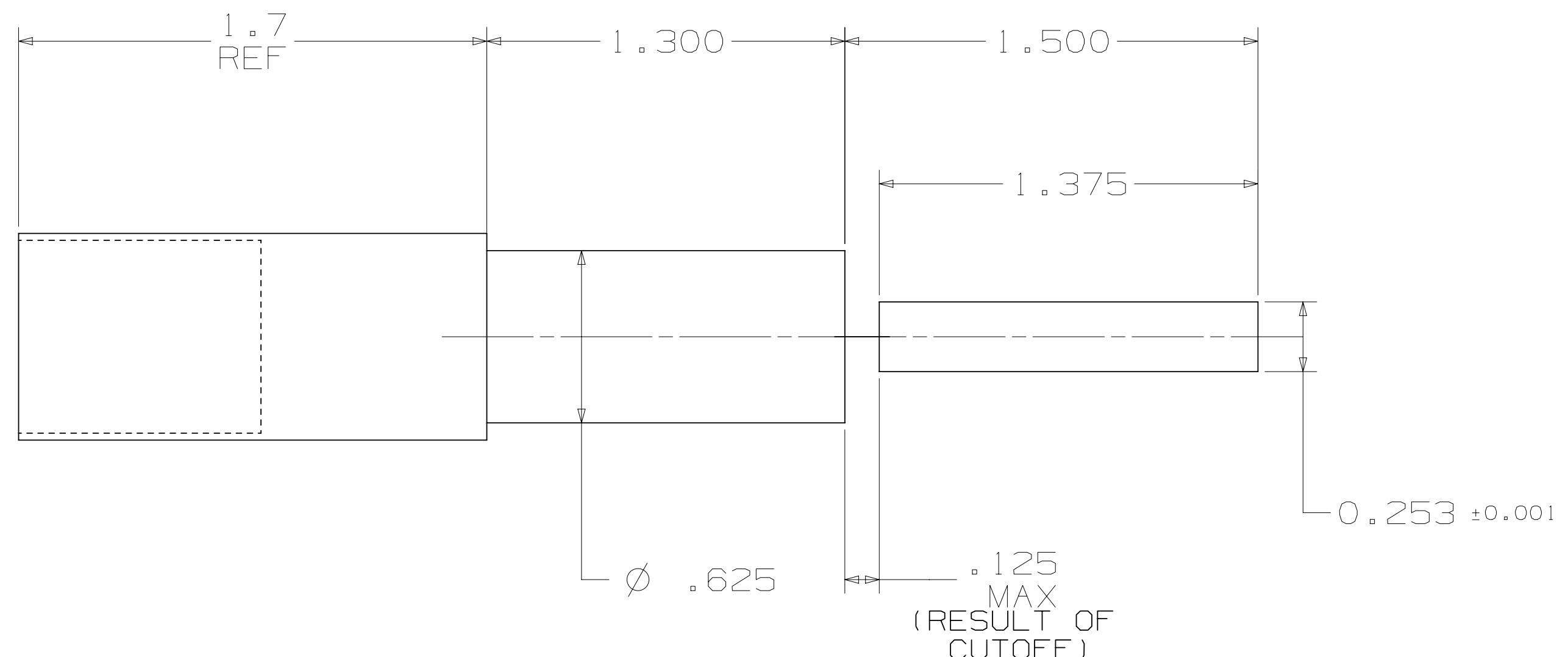
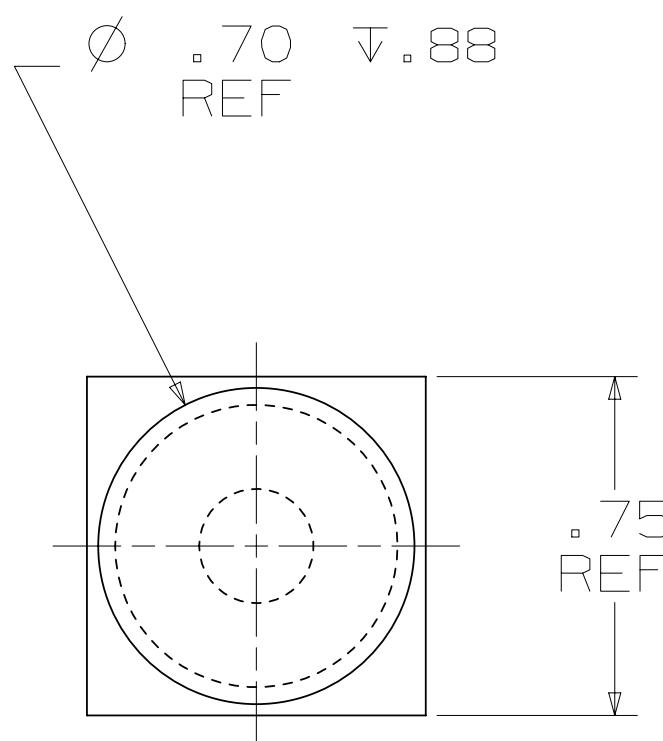
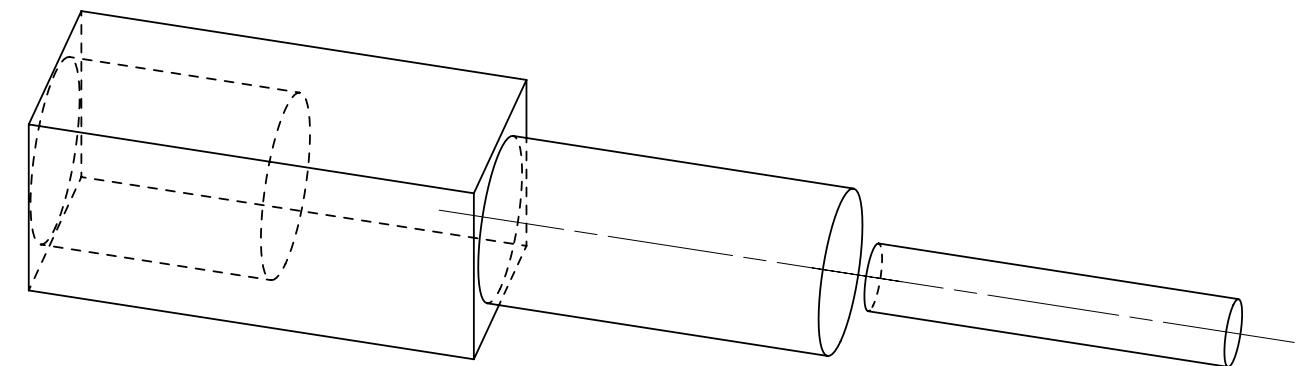
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2

1

UNCLASSIFIED

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
| | | | | | | | | |
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| | | | | | | | | |



TOLERANCES
DECIMALS

1 PLACE $\pm .030$
2 PLACE $\pm .010$
3 PLACE $\pm .005$
4 PLACE $\pm .0005$

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL :

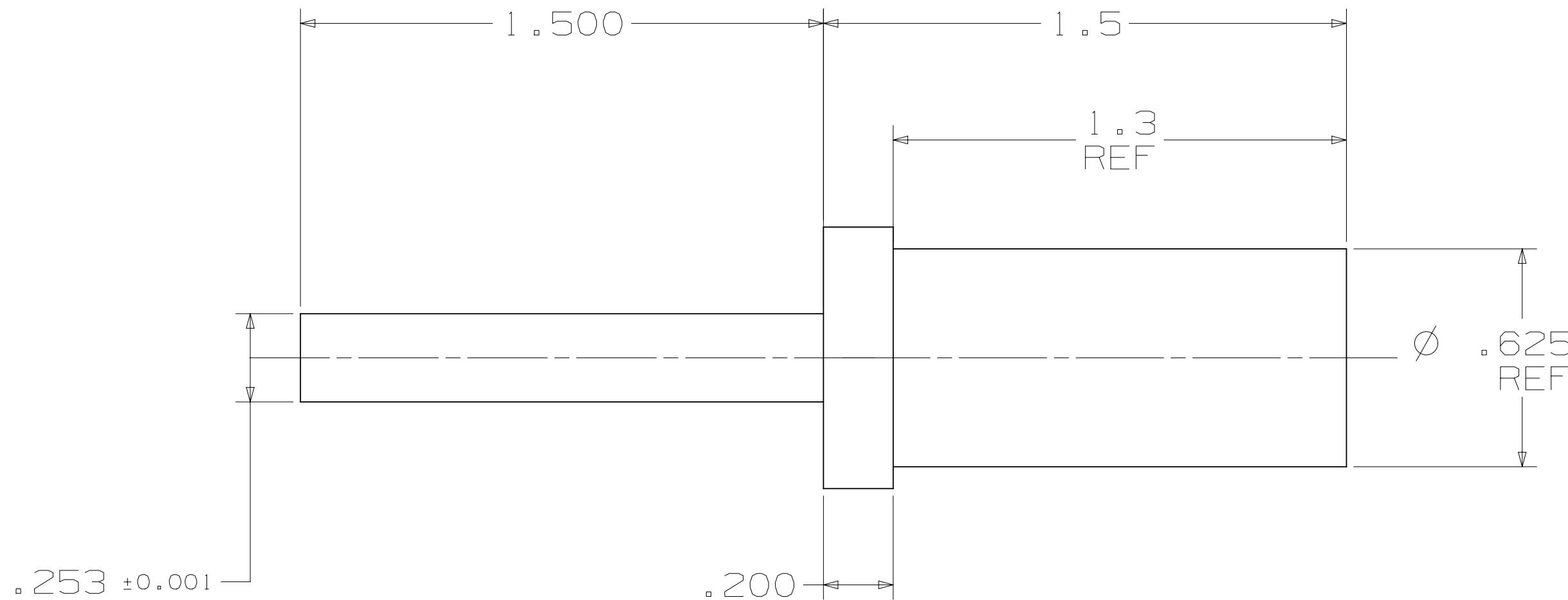
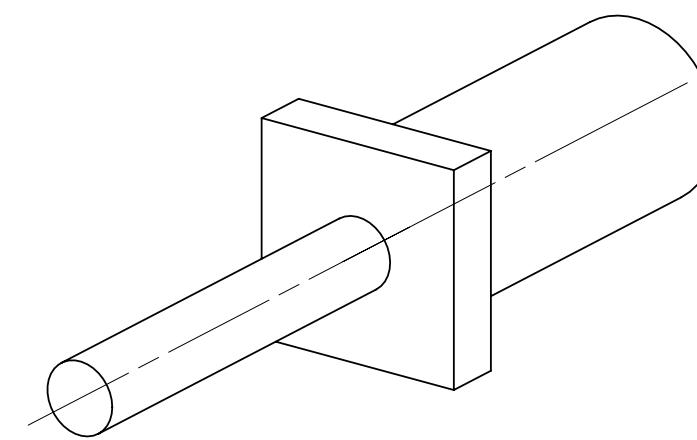
ANGULAR

$\pm 0^\circ 30'$
 $\pm 1/64$

| | | | | |
|-------------|-------------------|---|---------------------------|------------------|
| WG | CHANGE RESTRICTED | D<small>O</small> NOT S<small>C</small>E | | |
| USAGE: | | | FOCUS: HOPE | MANUFACTURING |
| | | | THIRD ANGLE PROJECTION | |
| DRAWN BY | B.T. | DATE | DWG NO. | PART NO. |
| CHECKED BY | R.Z. | 10/5/11 | T_A_1_T_SPECIMEN_IP30_DWG | X |
| RELEASED BY | | UNITS INCHES | SCALE N/A | SIZE C |
| | | | | DWG LEVEL 100 |
| | | | REV | SHEET 1 OF 1 |

IP30
DWG

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |



TOLERANCES
DECIMALS

1 PLACE ± .030
2 PLACE ± .010
3 PLACE ± .005
4 PLACE ± .0005

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL :

ANGULAR

± 0° 30'
FRACTIONS
± 1/64

| | | | |
|------------------------------|--|-----------------------------------|------------------|
| IP50 | | DWG | |
| CHANGE RESTRICTED | | DO NOT SCALE | |
| USAGE: ARMY-FSP | | FOCUS: HOPE MANUFACTURING | |
| DRAWN BY B.T. DATE 10/6/11 | | DWG NO. T_A_1_T_SPECIMEN_IP50_DWG | |
| CHECKED BY R.Z. DATE 10/6/11 | | PART NO. X | |
| RELEASED BY UNITS INCHES | | SCALE N/A | SIZE C |
| | | DWG LEVEL 100 | REV SHEET 1 OF 1 |

UNCLASSIFIED

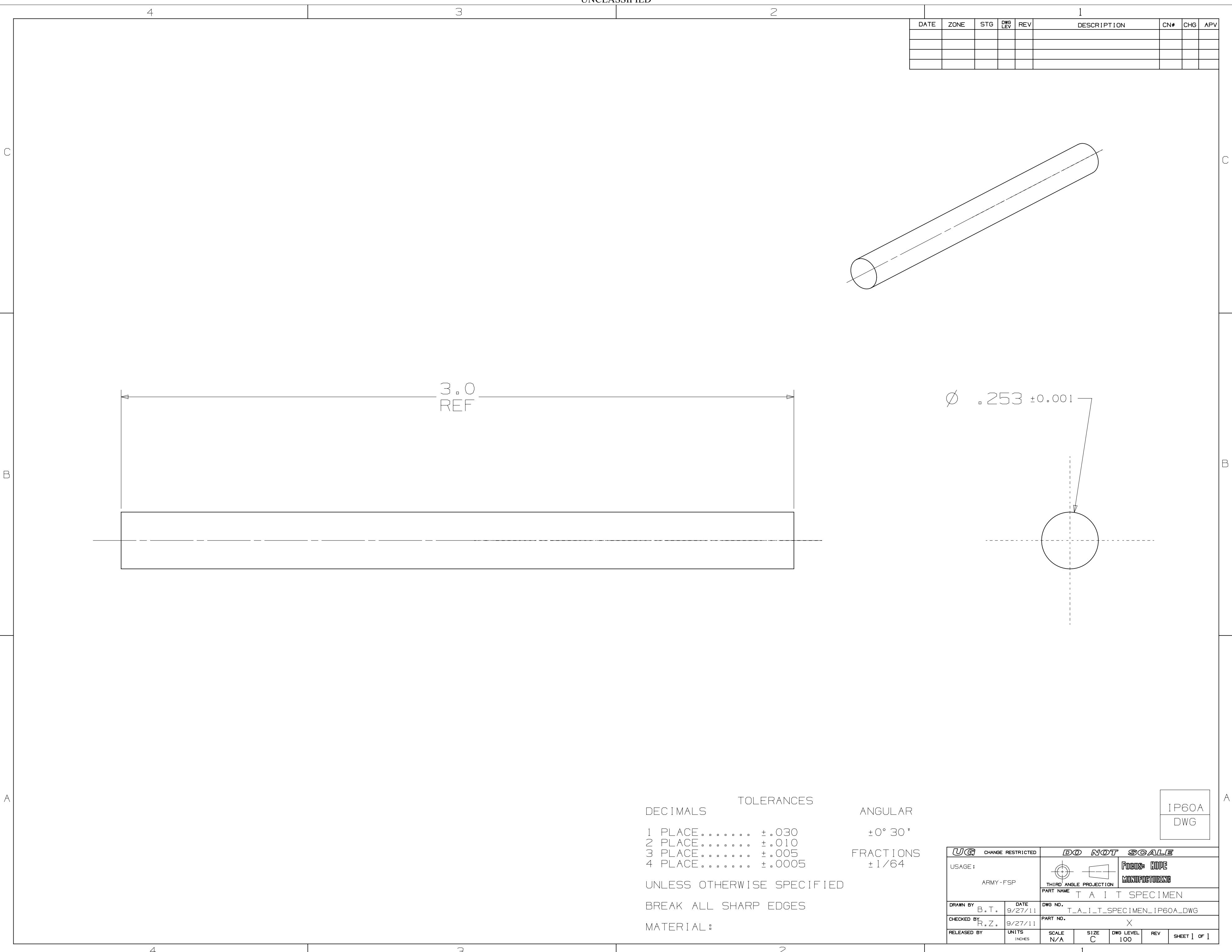
4

3

2

1

| DATE | ZONE | STG | DWG | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
| | | | | | | | | |
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4

3

2

1

UNCLASSIFIED

UNCLASSIFIED

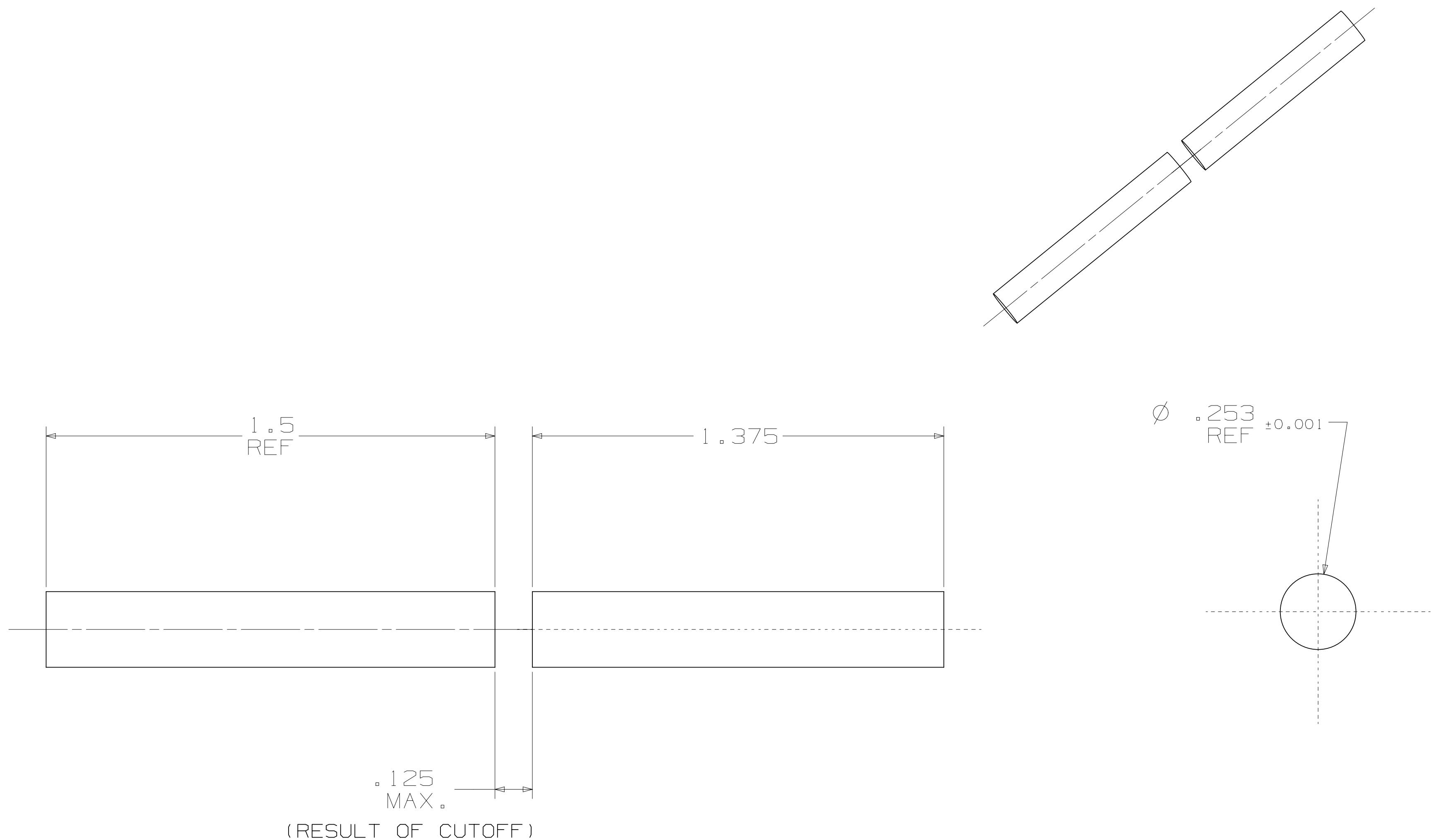
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3

2

1

| DATE | ZONE | STG | DWG | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |



(RESULT OF CUTOFF)

TOLERANCES
DECIMALS

- 1 PLACE $\pm .030$
 2 PLACE $\pm .010$
 3 PLACE $\pm .005$
 4 PLACE $\pm .0005$

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL :

ANGULAR

- $\pm 0^\circ 30'$
 $\pm 1/64$

| | | | |
|--------------------------|------------------|------------------------------|-----------|
| CHANGE RESTRICTED | | DO NOT SCALE | |
| USAGE: | | FOCUS: HOPE MANUFACTURING | |
| ARMY-FSP | | THIRD ANGLE PROJECTION | |
| PART NAME | T A I T SPECIMEN | DWG NO. | IP60B_DWG |
| DRAWN BY | B.T. | DATE | 10/6/11 |
| CHECKED BY | R.Z. | DATE | 10/6/11 |
| RELEASED BY | | UNITS | INCHES |
| | | SCALE | N/A |
| | | SIZE | C |
| | | DWG LEVEL | 100 |
| | | REV | |
| | | SHEET | 1 OF 1 |

4

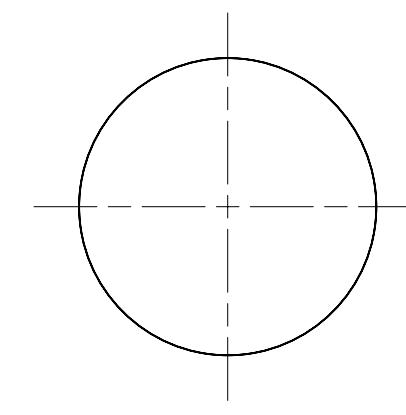
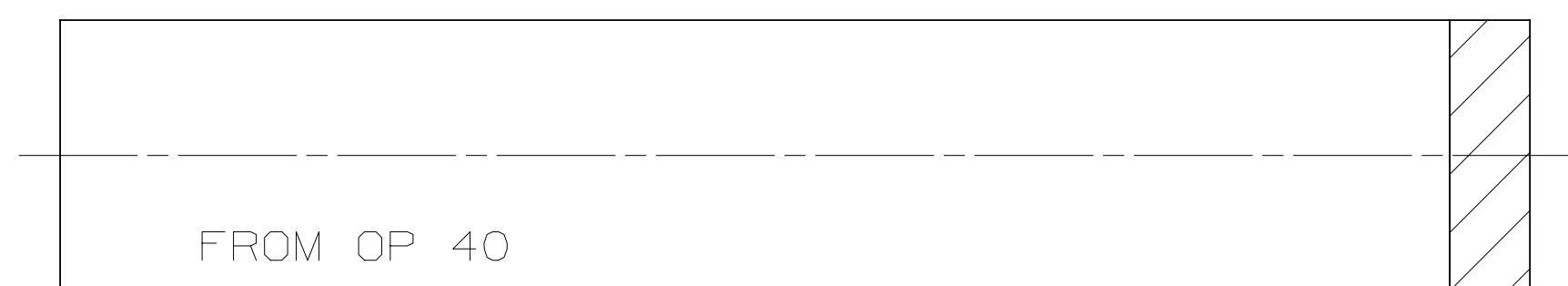
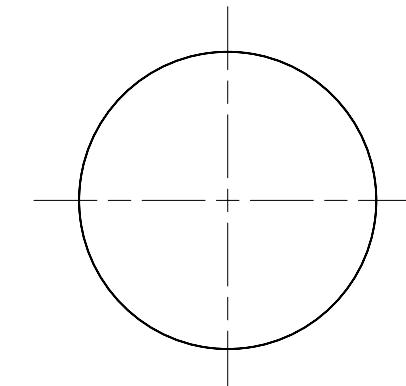
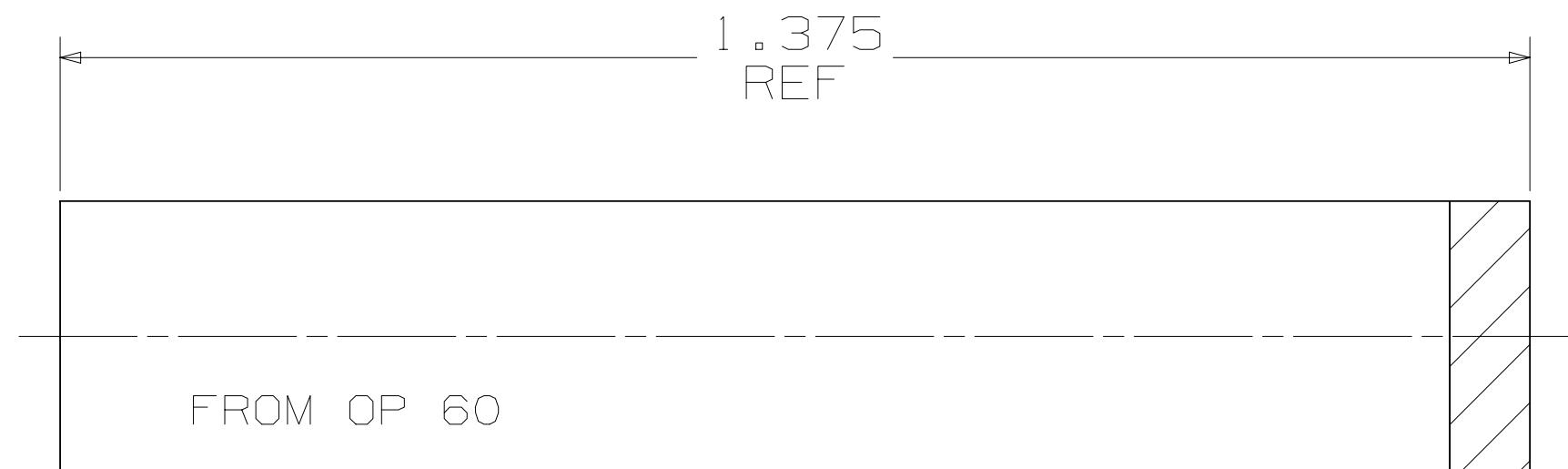
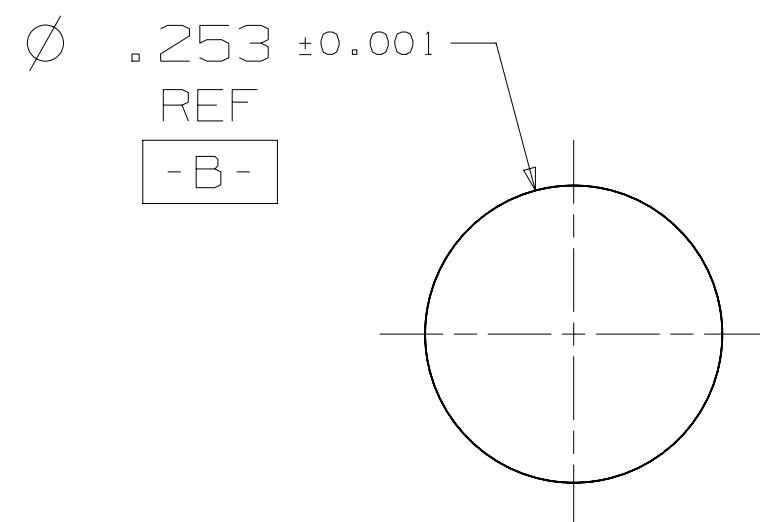
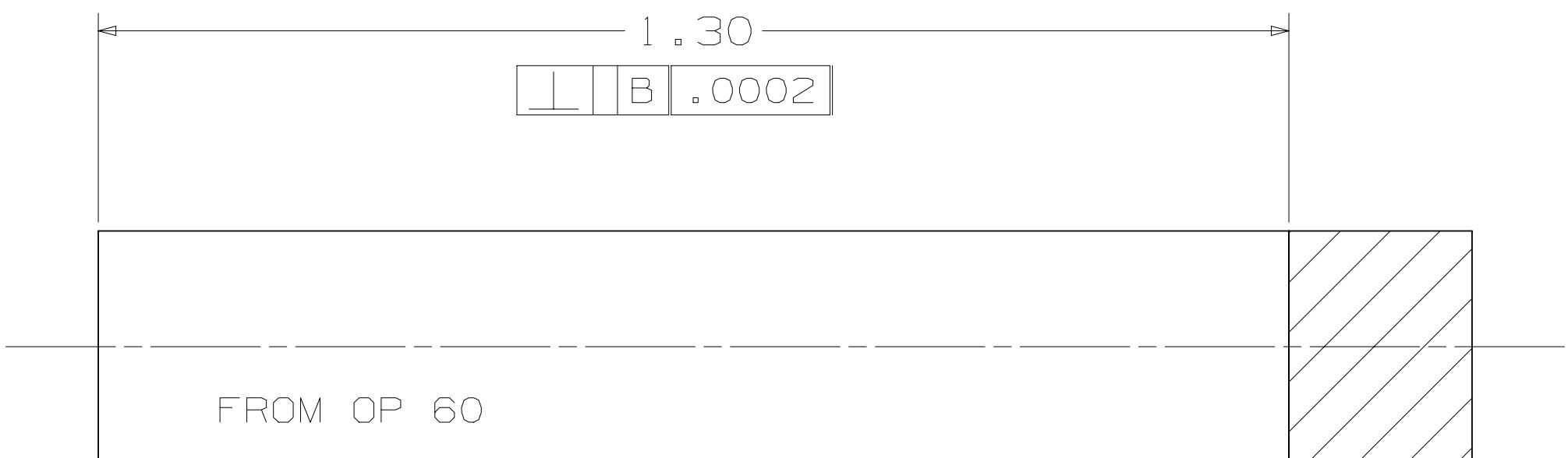
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1

UNCLASSIFIED

| DATE | ZONE | STG | DWG | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
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TOLERANCES
DECIMALS

1 PLACE ± .030
2 PLACE ± .010
3 PLACE ± .005
4 PLACE ± .0005

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL :

ANGULAR

± 0° 30'

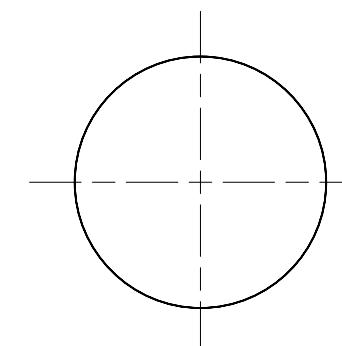
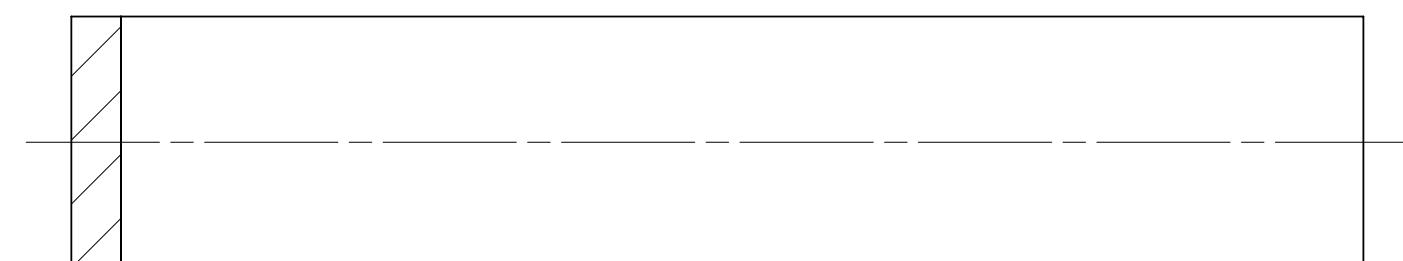
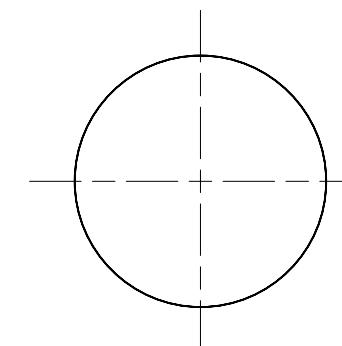
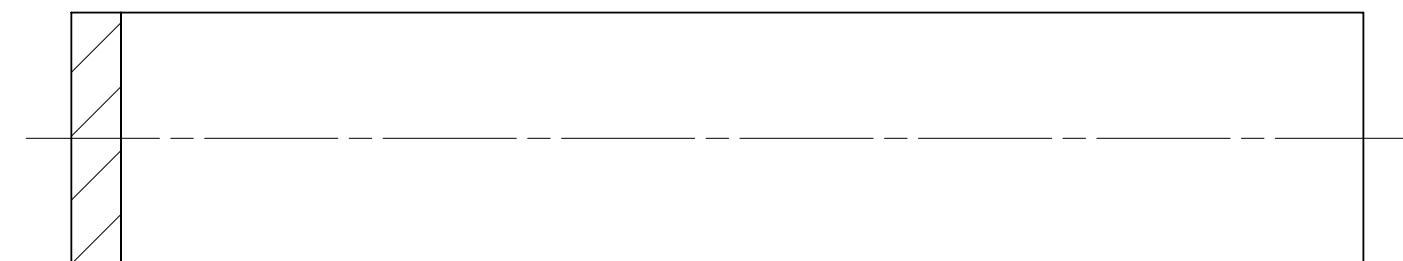
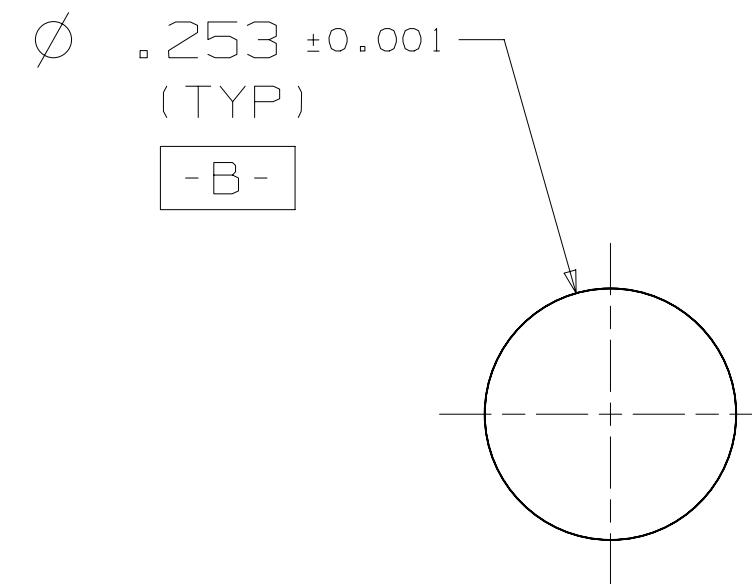
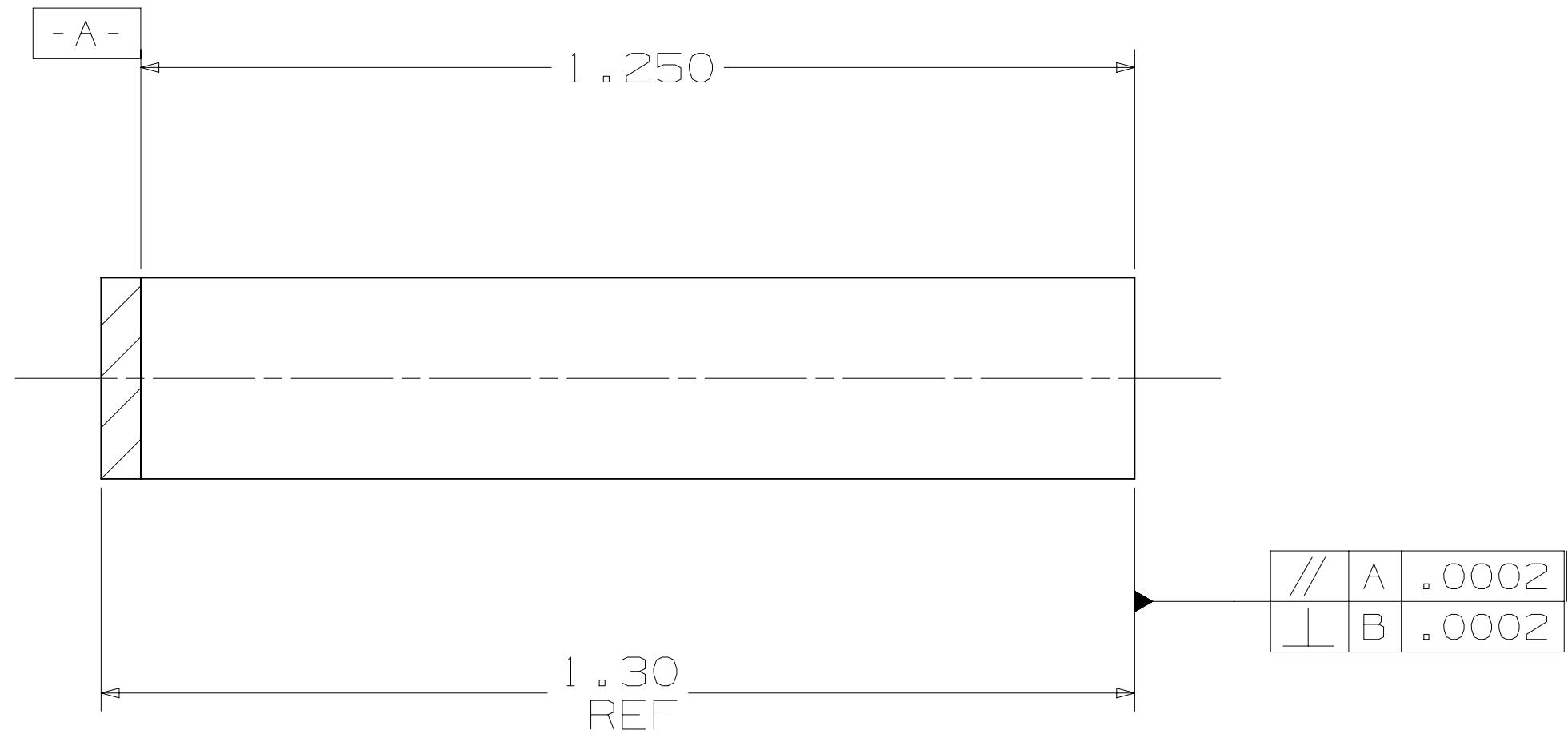
FRACTIONS

± 1/64

| | | |
|-----------------|-------------------|-----------------------------------|
| UGC | CHANGE RESTRICTED | DO NOT SCALE |
| USAGE: | | FOCUS: HOPE MANUFACTURING |
| ARMY-FSP | | THIRD ANGLE PROJECTION |
| DRAWN BY B.T. | | DWG NO. T_A_1_T_SPECIMEN_IP80_DWG |
| CHECKED BY R.Z. | | PART NO. X |
| RELEASED BY | UNITS INCHES | SCALE N/A |
| | | SIZE C |
| | | DWG LEVEL 100 |
| | | REV |
| | | SHEET 1 OF 1 |

IP80
DWG

COMPLETION OF PROCESS RESULTS IN 3 PIECES



TOLERANCES

DECIMALS

1 PLACE ± .030
2 PLACE ± .010
3 PLACE ± .005
4 PLACE ± .0005

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL:

ANGULAR

± 0° 30'

FRACTIONS

± 1/64

IP90
DWG

| CHANGE RESTRICTED | | DO NOT SCALE | |
|-------------------|------|---------------------------|---------------------------|
| USAGE: | | FOCUS: HOPE MANUFACTURING | |
| ARMY-FSP | | THIRD ANGLE PROJECTION | |
| DRAWN BY | B.T. | DATE | DWG NO. |
| CHECKED BY | R.Z. | 10/7/11 | T_A_1_T_SPECIMEN_IP90_DWG |
| RELEASED BY | | UNITS INCHES | PART NO. |
| | | SCALE N/A | X |
| | | SIZE C | DWG LEVEL 100 |
| | | REV | SHEET 1 OF 1 |

UNCLASSIFIED

Focus: HOPE Process routing/Shop travelerCustomer: **Southwest Research Institute**

Street Address:

City State Zip:

Stock: **3/4 x 3/4 x 4 1/2 coupon (8)**Part Number: **A-250in_SmoothTensile**Description: **Johnson-Cook test specimen**

Revision:

| Op No | Labor Code | Operation Description |
|-------|------------|--|
| | | See 'Strips' Process Sheet for initial specimen extraction operations. |
| | | Extreme care must be taken to keep Specimen Types R, W, and A, and Materials 6061 and 5083 properly segregated. THIS IS EXTREMELY IMPORTANT, |
| 10 | | Confirm that all material blocks are marked "6061-W" |
| 20 | Mill | Square mill end, round (circular interpolate) end to 0.70 dia x 0.88 and center drill |
| 30 | Laser | Mark end "61W-#" (where # = 1 thru 8) |
| 40 | Mazak | center drill, rough contour turn, final contour turn, single point thread |
| 50 | Laser | Mark end "61W-#" (where # = 1 thru 8) |
| 60 | | Individually bag each part |
| 70 | | Label Bags |
| 80 | | Polish Longitudinally |
| 90 | Mazak | Cover polished area with rubber hose. Cut-off to final length 3.000 |
| | | |

UNCLASSIFIED

UNCLASSIFIED

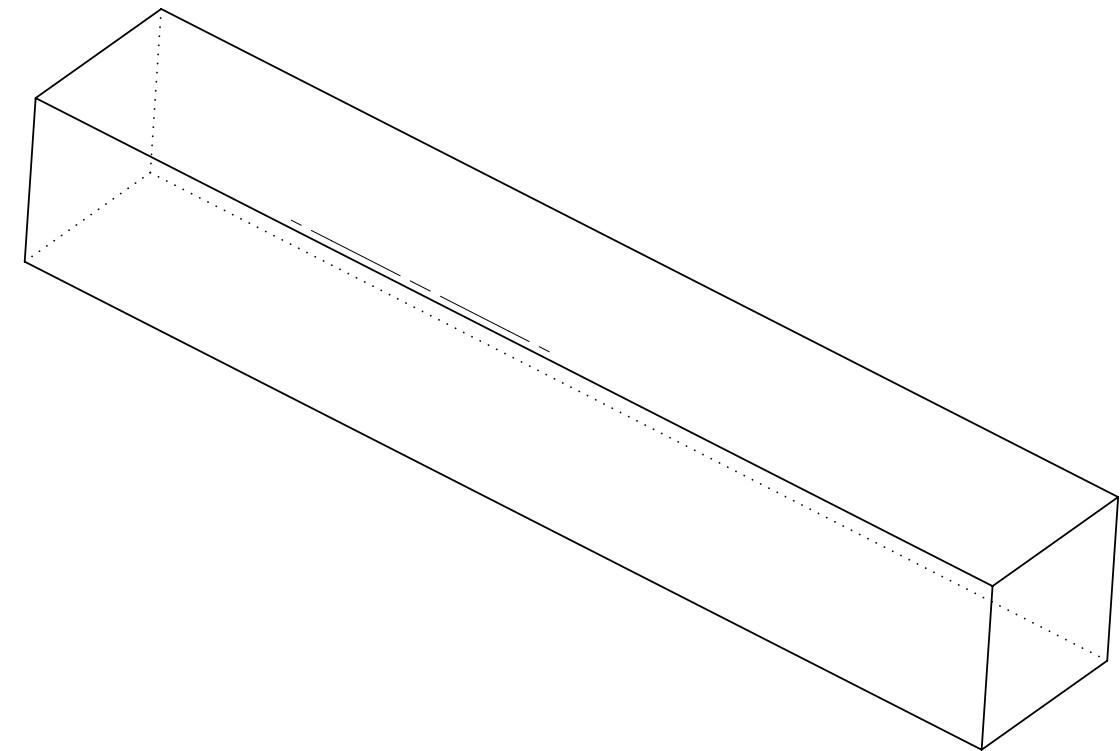
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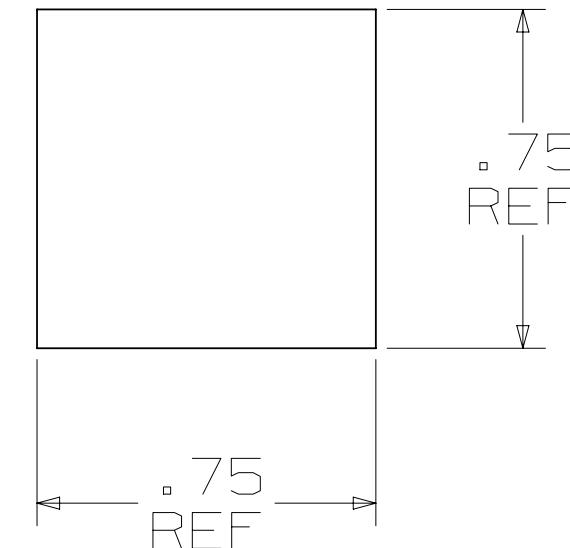
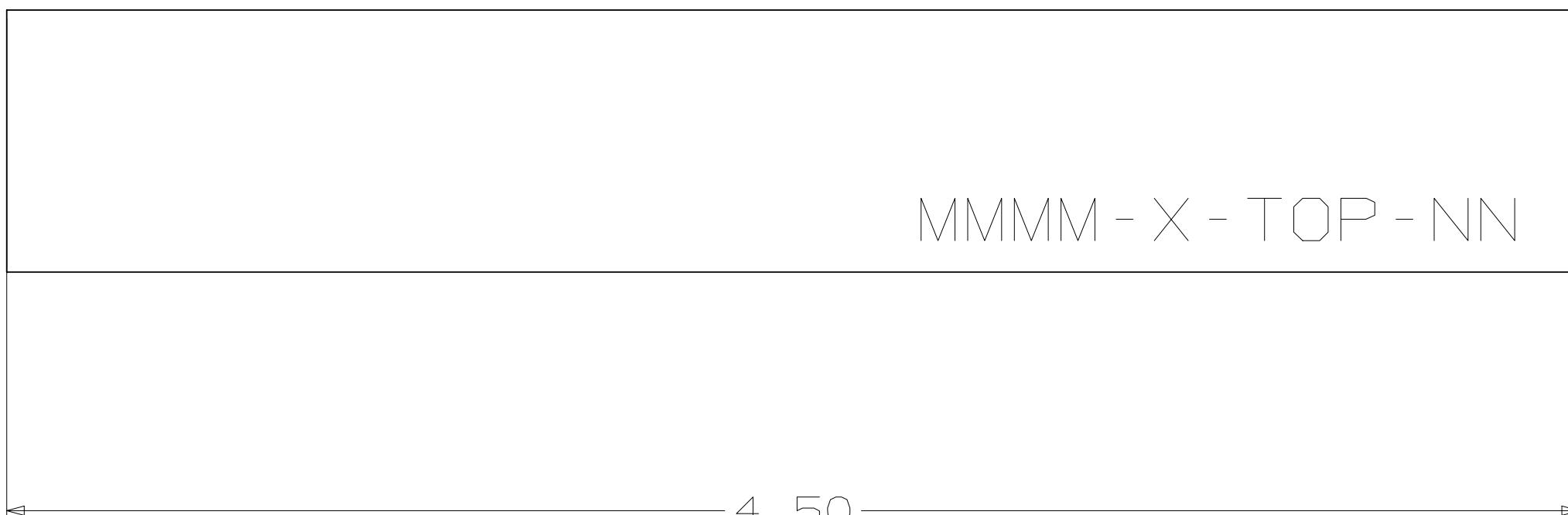
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| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
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MMMM-X-TOP-NN

4.50
REFIP10
DWG

TOLERANCES

DECIMALS

- 1 PLACE $\pm .030$
 2 PLACE $\pm .010$
 3 PLACE $\pm .003$
 4 PLACE $\pm .0005$

ANGULAR

 $\pm 0^\circ 30'$

- FRACTIONS
 $\pm 1/64$

UNLESS OTHERWISE SPECIFIED

MATERIAL:

| | | |
|------------------------|------------------------|---|
| UG | CHANGE RESTRICTED | DO NOT SCALE |
| USAGE: | | FOCUS: HOPE |
| ARMY-FSP | | MANUFACTURING |
| THIRD ANGLE PROJECTION | | |
| PART NAME | A 250IN SMOOTH TENSILE | |
| DRAWN BY | B.T. | DATE |
| CHECKED BY | R.Z. | 10/4/11 |
| RELEASED BY | | DWG NO. A_250IN_SMOOTH TENSILE_IP10_DWG |
| | | PART NO. |
| | | SCALE N/A |
| | | SIZE C |
| | | DWG LEVEL 100 |
| | | REV |
| | | SHEET 1 OF 1 |

4

3

2

1

UNCLASSIFIED

UNCLASSIFIED

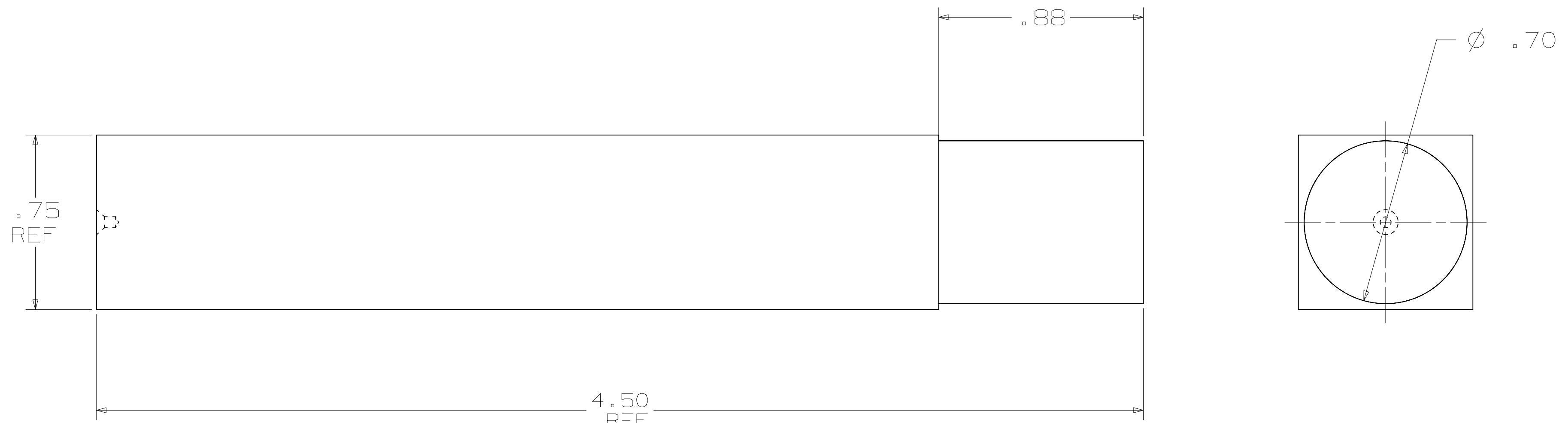
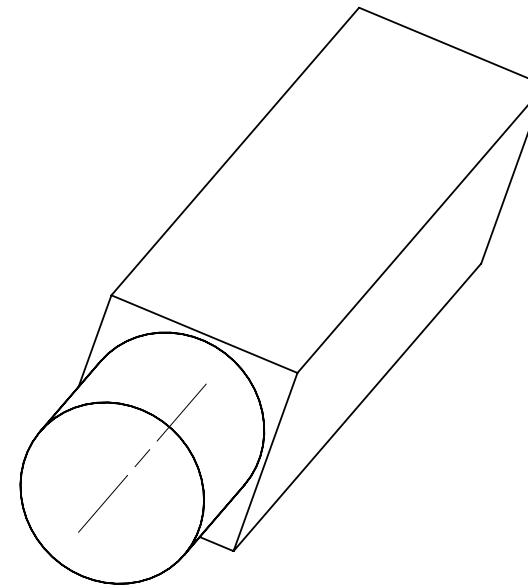
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| DATE | ZONE | STG | Dwg | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
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TOLERANCES

DECIMALS

- | | |
|---------------|---------|
| 1 PLACE | ± .030 |
| 2 PLACE | ± .010 |
| 3 PLACE | ± .003 |
| 4 PLACE | ± .0005 |

UNLESS OTHERWISE SPECIFIED

MATERIAL:

ANGULAR

- | |
|-----------|
| ± 0° 30' |
| FRACTIONS |
| ± 1/64 |

IP20
DWG

| | |
|--------------------|--|
| CHANGE RESTRICTED | DO NOT SCALE |
| USAGE: ARMY FSP | FOCUS: HOPE MANUFACTURING |
| DRAWN BY B.T. | DATE 10/4/11 |
| CHECKED BY R.Z. | DATE 10/4/11 |
| RELEASED BY | Dwg No. A_250IN_SMOOTH TENSILE_IP20_DWG |
| | Part No. |
| | Scale N/A |
| | Size C |
| | Dwg Level 100 |
| | Rev |
| | Sheet 1 of 1 |

4

3

2

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UNCLASSIFIED

UNCLASSIFIED

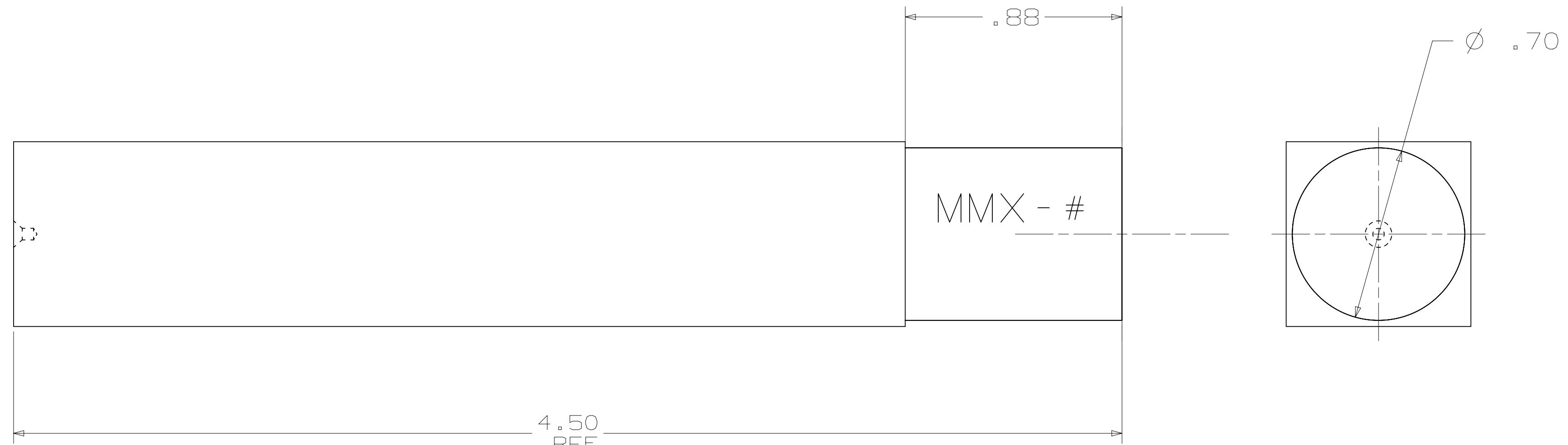
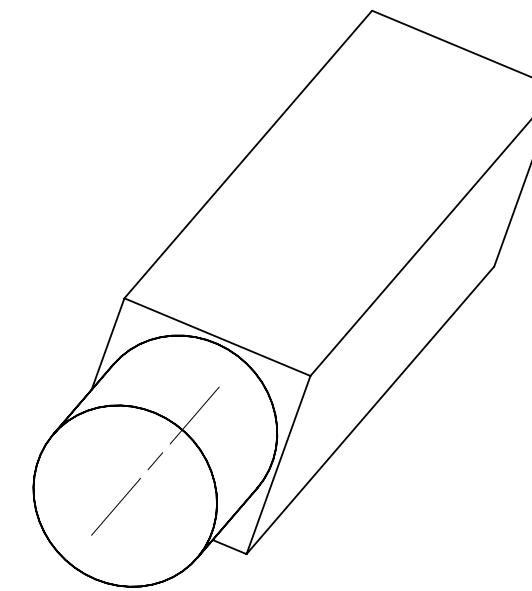
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1

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
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TOLERANCES

DECIMALS

- | | |
|---------------|-------------|
| 1 PLACE | $\pm .030$ |
| 2 PLACE | $\pm .010$ |
| 3 PLACE | $\pm .003$ |
| 4 PLACE | $\pm .0005$ |

UNLESS OTHERWISE SPECIFIED

MATERIAL:

ANGULAR

 $\pm 0^\circ 30'$

FRACTIONS

 $\pm 1/64$

IP30

DWG

| | | |
|-----------------|-------------------|---|
| WG | CHANGE RESTRICTED | DO NOT SCALE |
| USAGE: | | FOCUS: HOPE MANUFACTURING |
| ARMY FSP | | THIRD ANGLE PROJECTION |
| DRAWN BY B.T. | DATE 10/4/11 | DWG NO. A_250IN_SMOOTH TENSILE_IP30_DWG |
| CHECKED BY R.Z. | 10/4/11 | PART NO. |
| RELEASED BY | | SCALE N/A |
| | | SIZE C |
| | | DWG LEVEL 100 |
| | | REV |
| | | SHEET 1 OF 1 |

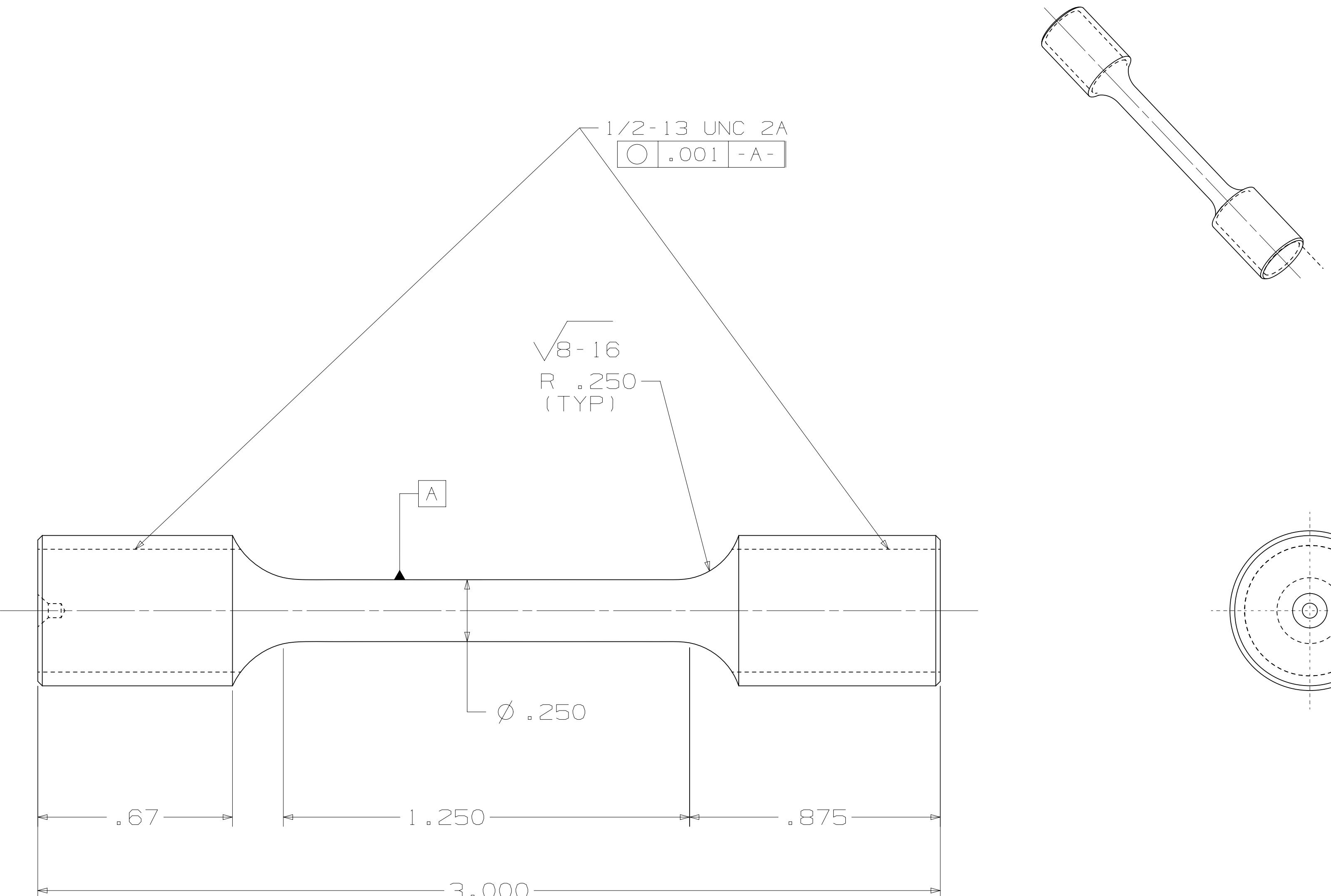
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UNCLASSIFIED

IP40
DWGTOLERANCES (INCH)
DECIMALS

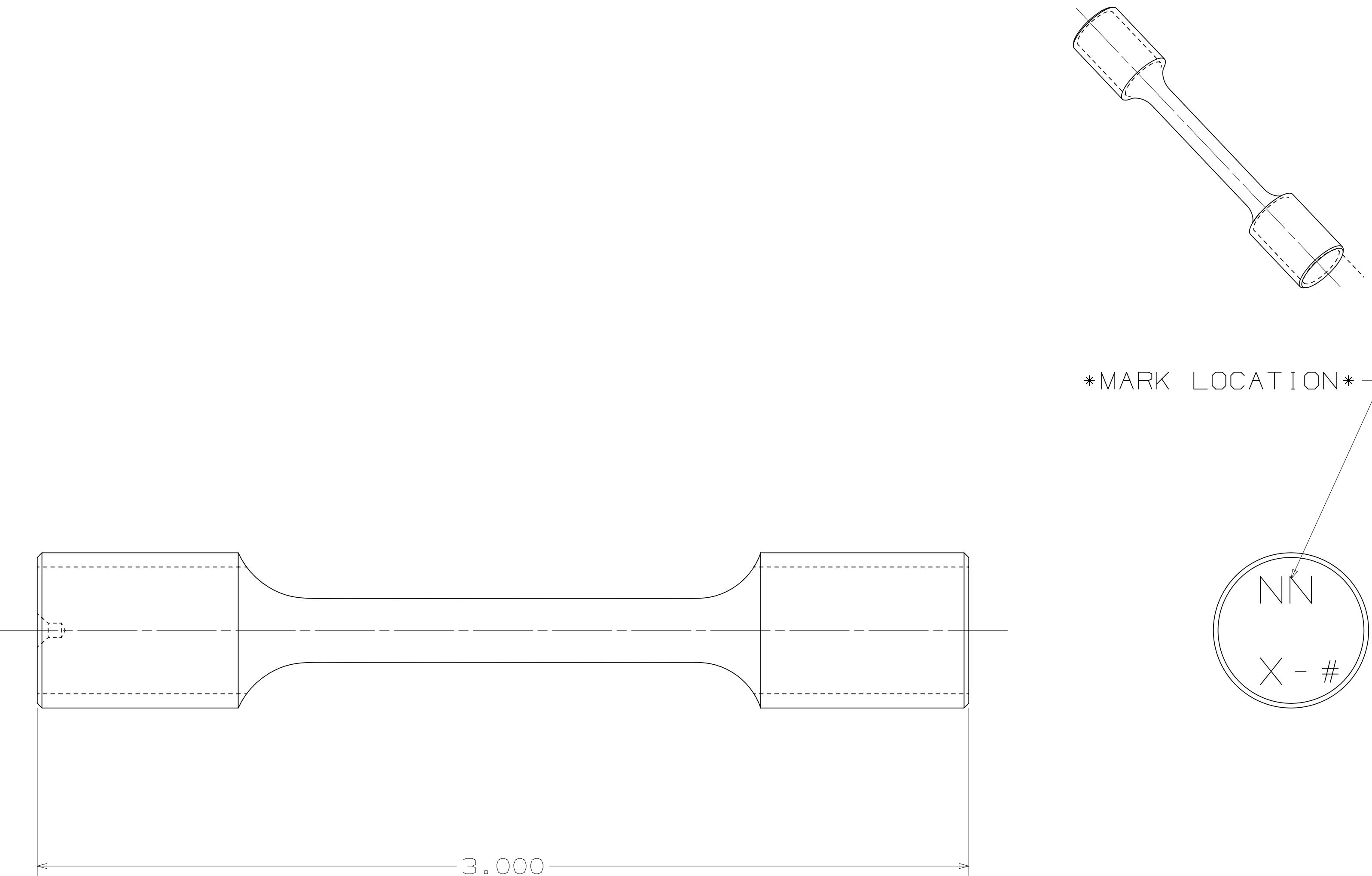
| | |
|---------------|---------|
| 1 PLACE | ± .030 |
| 2 PLACE | ± .010 |
| 3 PLACE | ± .003 |
| 4 PLACE | ± .0005 |

ANGULAR
±0° 30'FRACTIONS
±1/64

UNLESS OTHERWISE SPECIFIED

MATERIAL:

| UG CHANGE RESTRICTED | | DO NOT SCALE | | FOCUS: HOPE MANUFACTURING | |
|----------------------|----------|------------------------|------------|---------------------------|---------------------------------|
| USAGE: | ARMY FSP | THIRD ANGLE PROJECTION | PART NAME: | A 250IN SMOOTH TENSILE | |
| DRAWN BY | B.T. | DATE | 10/4/11 | DWG NO. | A_250IN_SMOOTH TENSILE_IP40_DWG |
| CHECKED BY | R.Z. | 10/4/11 | | PART NO. | |
| RELEASED BY | | SCALE | N/A | SIZE | C |
| | | REV | | DWG LEVEL | 100 |
| | | SHEET | 1 | REV | SHEET 1 OF 1 |



TOLERANCES (INCH)
DECIMALS

1 PLACE $\pm .030$
 2 PLACE $\pm .010$
 3 PLACE $\pm .003$
 4 PLACE $\pm .0005$

ANGULAR
 $\pm 0^\circ 30'$

FRACTIONS
 $\pm 1/64$

UNLESS OTHERWISE SPECIFIED

MATERIAL:

IP50
DWG

| UG CHANGE RESTRICTED | | DO NOT SCALE | |
|----------------------|------|-----------------------------------|--------------------------------|
| USAGE: | | FOCUS: HOPE MANUFACTURING | |
| ARMY FSP | | PART NAME: A 250IN SMOOTH TENSILE | |
| DWG NO. | B.T. | DATE | A_250IN_SMOOTHTESTILE_IP50_DWG |
| CHECKED BY | R.Z. | 10/4/11 | PART NO. |
| RELEASED BY | | SCALE N/A | SIZE C |
| | | DWG LEVEL 100 | REV 1 |
| | | | SHEET 1 OF 1 |

UNCLASSIFIED

Focus: HOPE Process routing/Shop traveler

Customer: **TACOM Warren**

Street Address:

City State Zip:

Stock: **.650 x 2.525" FSW weld coupon (4)**

Part Number: **.375 Compression Specimen (SHPBC)**

Description: **Split Hopkinson Pressure Bar test specimen**

Revision:

| Op No | Labor Code | Operation Description |
|-------|------------|--|
| | | See Torsion Process Sheet for initial specimen extraction operations. |
| | | Extreme care must be taken to keep Specimen Types R, W, and A, and Materials 6061 and 5083 properly segregated. THIS IS EXTREMELY IMPORTANT, |
| 10 | | Confirm that all material blocks are marked "6061-W" |
| 20 | CNC | Turn to 0.375 dia x 1.5 |
| 30 | CNC | Turn to .375 dia.x 1.325; cut-off at 1.2 |
| | | DO NOT mark the final part in any way (laser, paint, etc.) |
| 40 | | Individually bag each part and mark each bag "61W" |
| 50 | CNC | Face mill end; clean surface |
| 60 | CNC | Face mill end to final length |
| | | |

UNCLASSIFIED

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| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
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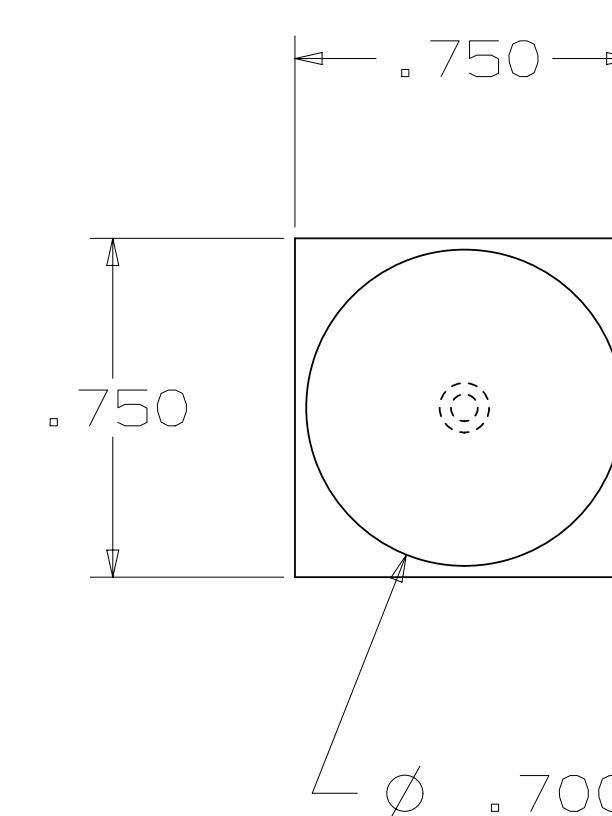
UNCLASSIFIED

CENTER FOR
TURNING

.750

4.5 REF

.88



TOLERANCES

DECIMALS

- 1 PLACE ± .030
 2 PLACE ± .010
 3 PLACE ± .005
 4 PLACE ± .0005

ANGULAR
± 0° 30'FRACTIONS
± 1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL :

IP10
DWG

| | | |
|-----------------|-------------------|------------------------------|
| WG | CHANGE RESTRICTED | DO NOT SCALE |
| USAGE: | | FOCUS: HOPE MANUFACTURING |
| ARMY - FSP | | THIRD ANGLE PROJECTION |
| DRAWN BY B.T. | DATE 11/2/11 | DWG NO. SHPBC_IP10_DWG |
| CHECKED BY R.Z. | 11/2/11 | PART NO. |
| RELEASED BY | UNITS INCHES | SCALE N/A |
| | | SIZE C |
| | | DWG LEVEL 100 |
| | | REV |
| | | SHEET 1 OF 1 |

UNCLASSIFIED

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| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
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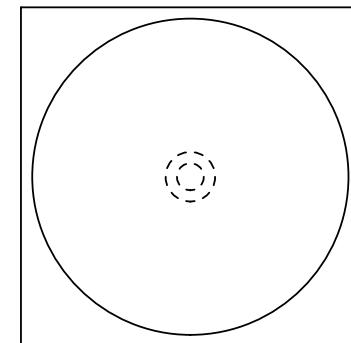
C

C



B

B



A

A

.098

TOLERANCES

DECIMALS

- 1 PLACE $\pm .030$
 2 PLACE $\pm .010$
 3 PLACE $\pm .005$
 4 PLACE $\pm .0005$

ANGULAR
 $\pm 0^\circ 30'$ FRACTIONS
 $\pm 1/16$

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL:

| | | |
|------------------|------------------------|------------------------------|
| WG | CHANGE RESTRICTED | DO NOT SCALE |
| USAGE: | | FOCUS: HOPE MANUFACTURING |
| ARMY - FSP | THIRD ANGLE PROJECTION | PART NAME: SHPBC |
| DRAWN BY: B.T. | DATE: 11/3/11 | DWG NO.: SHPBC_IP20_DWG |
| CHECKED BY: R.Z. | 11/3/11 | PART NO. |
| RELEASED BY: | UNITS: INCHES | SCALE: N/A |
| | | SIZE: C |
| | | DWG LEVEL: 100 |
| | | REV: 1 |
| | | SHEET 1 OF 1 |

IP20
DWG

4

3

2

1

UNCLASSIFIED

UNCLASSIFIED

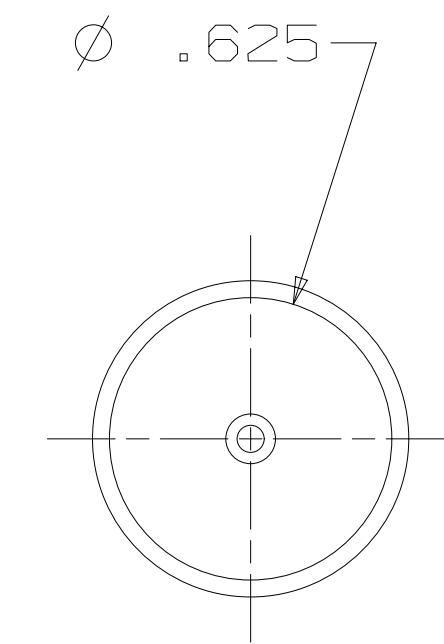
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| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
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TOLERANCES
DECIMALS

| | |
|---------------|---------|
| 1 PLACE | ± .030 |
| 2 PLACE | ± .010 |
| 3 PLACE | ± .005 |
| 4 PLACE | ± .0005 |

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL:

ANGULAR
± 0° 30'
FRACTIONS
± 1/16

| | | |
|-------------|-------------------|------------------------------|
| UGC | CHANGE RESTRICTED | DO NOT SCALE |
| USAGE: | | FOCUS: HOPE MANUFACTURING |
| ARMY - FSP | | THIRD ANGLE PROJECTION |
| DRAWN BY | B.T. | DATE |
| CHECKED BY | R.Z. | 11/3/11 |
| RELEASED BY | | PART NO. |
| | UNITS INCHES | SCALE N/A |
| | | SIZE C |
| | | DWG LEVEL 100 |
| | | REV |
| | | SHEET 1 OF 1 |

IP30
DWG

4

3

2

1

UNCLASSIFIED

UNCLASSIFIED

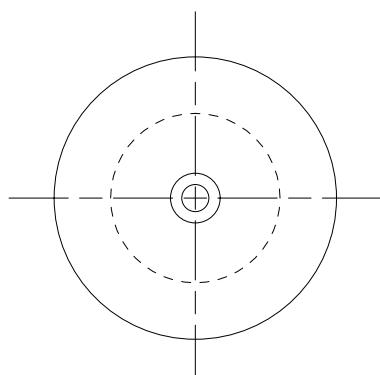
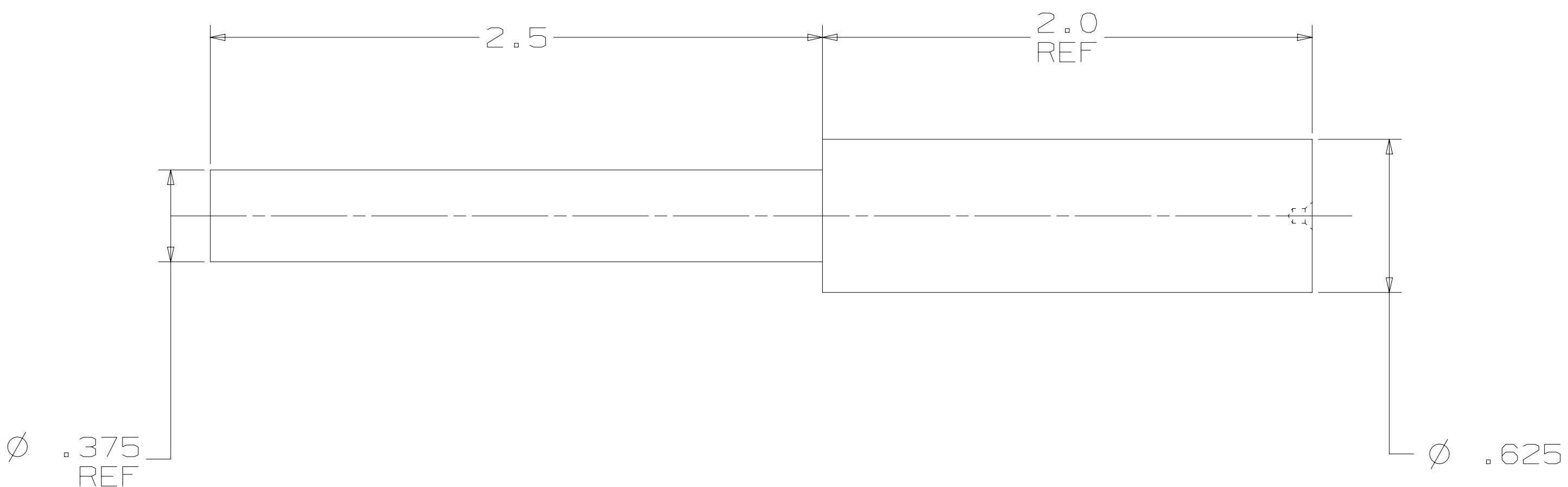
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| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
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TOLERANCES

DECIMALS

- | | |
|---------------|-------------|
| 1 PLACE | $\pm .030$ |
| 2 PLACE | $\pm .010$ |
| 3 PLACE | $\pm .005$ |
| 4 PLACE | $\pm .0005$ |

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL:

ANGULAR
 $\pm 0^\circ 30'$ FRACTIONS
 $\pm 1/16$
 IP40
DWG

| CHANGE RESTRICTED | | DO NOT SCALE | | FOCUS: HOPE MANUFACTURING | |
|-------------------|------|--------------|---------|---------------------------|----------------|
| USAGE: | | | | THIRD ANGLE PROJECTION | SHPBC |
| ARMY - FSP | | | | | |
| DRAWN BY | B.T. | DATE | 11/3/11 | DWG NO. | SHPBC_IP40_DWG |
| CHECKED BY | R.Z. | DATE | 11/3/11 | PART NO. | |
| RELEASED BY | | UNITS | N/A | SCALE | N/A |
| | | INCHES | | SIZE | C |
| | | | | DWG LEVEL | 100 |
| | | | | REV | |
| | | | | SHEET | 1 OF 1 |

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UNCLASSIFIED

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
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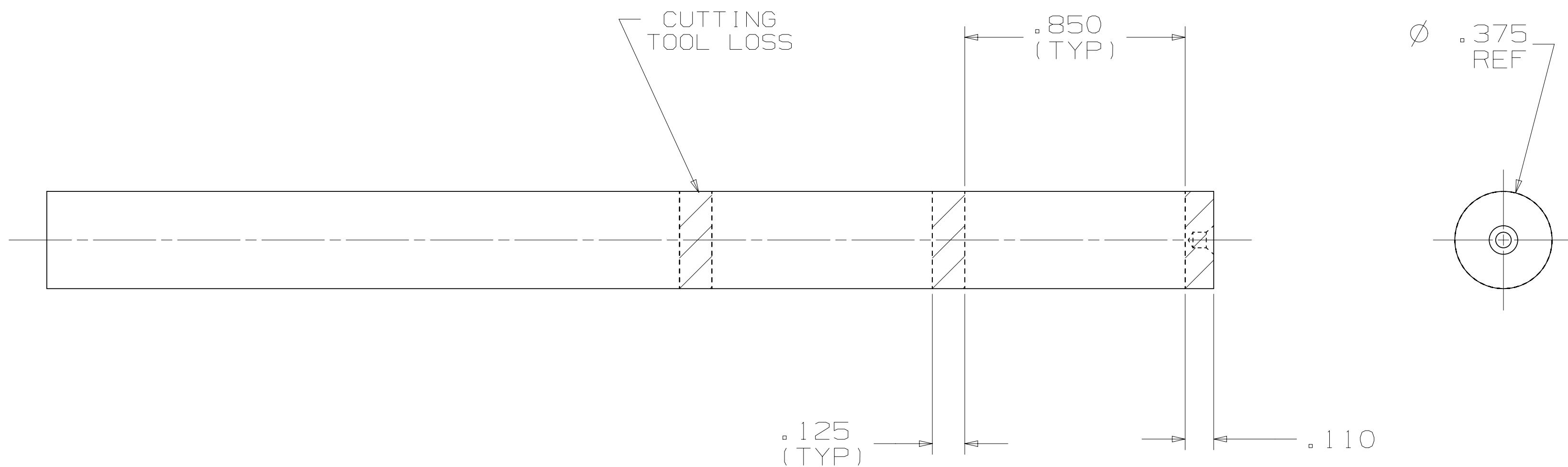
C

B

B

A

A



TOLERANCES

DECIMALS

- 1 PLACE ± .030
 2 PLACE ± .010
 3 PLACE ± .005
 4 PLACE ± .0005

UNLESS OTHERWISE SPECIFIED

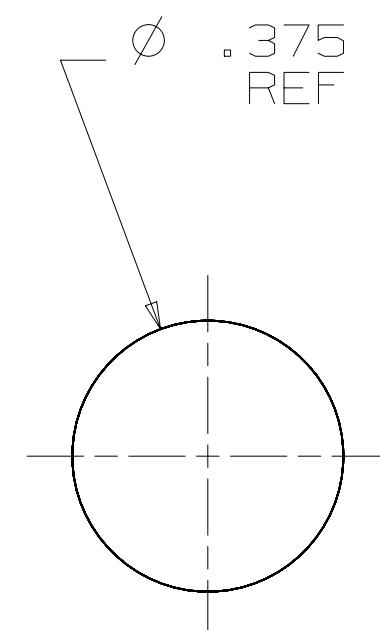
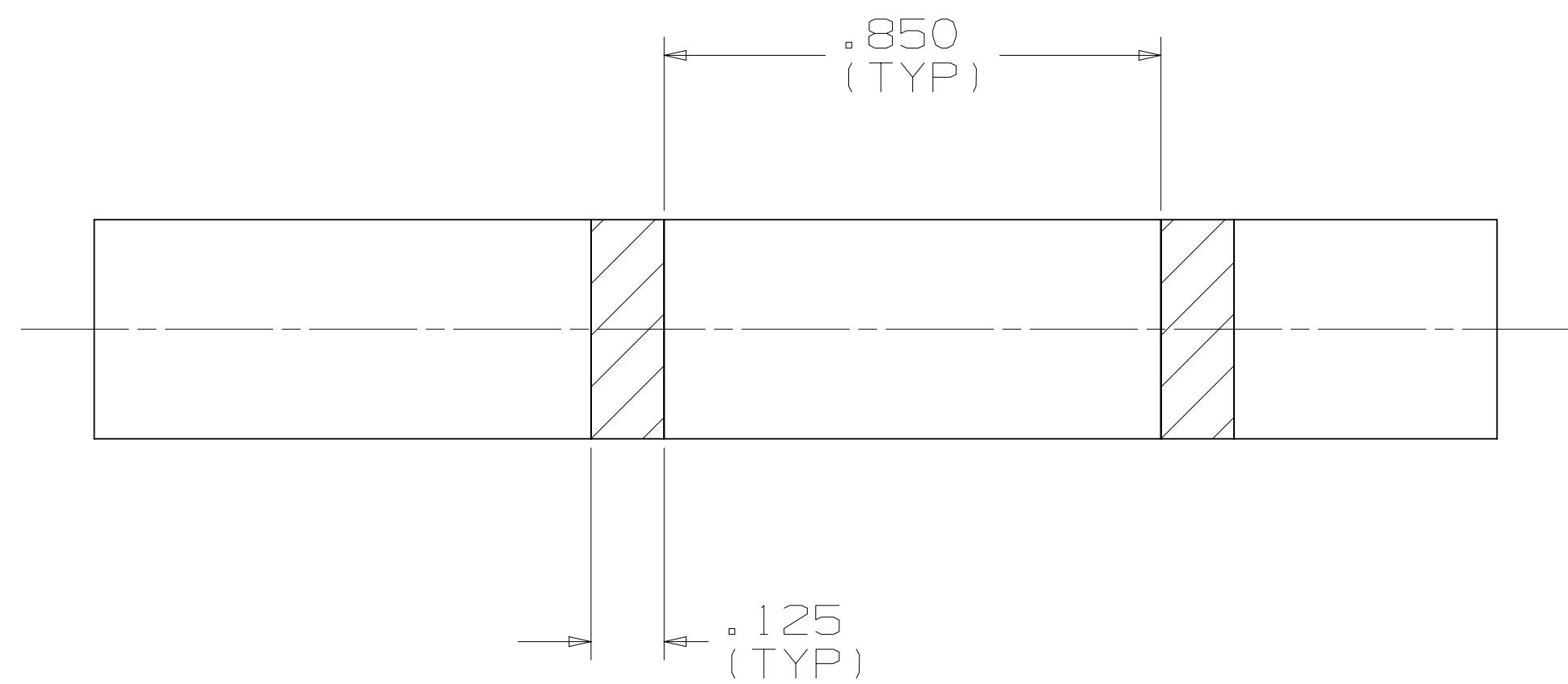
BREAK ALL SHARP EDGES

MATERIAL:

ANGULAR
 $\pm 0^\circ 30'$ FRACTIONS
 $\pm 1/16$
 IP50
 DWG

| CHANGE RESTRICTED | | DO NOT SCALE | | FOCUS: HOPE MANUFACTURING | |
|-------------------|------|--------------|---------|------------------------------|----------------|
| USAGE: | | | | THIRD ANGLE PROJECTION | SHPBC |
| ARMY - FSP | | | | | |
| DRAWN BY | B.T. | DATE | 11/3/11 | DWG NO. | SHPBC_IP50_DWG |
| CHECKED BY | R.Z. | DATE | 11/3/11 | PART NO. | |
| RELEASED BY | | UNITS | INCHES | SCALE | N/A |
| | | | | SIZE | C |
| | | | | DWG LEVEL | 100 |
| | | | | REV | |
| | | | | SHEET | 1 OF 1 |

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
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| | | | | | | | | |
| | | | | | | | | |



TOLERANCES
DECIMALS

1 PLACE ± .030
2 PLACE ± .010
3 PLACE ± .005
4 PLACE ± .0005

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL:

ANGULAR
± 0° 30'
FRACTIONS
± 1/16

| | | |
|-------------|-------------------|------------------------------|
| UGC | CHANGE RESTRICTED | D O NOT SCALE |
| USAGE: | | FOCUS: HOPE MANUFACTURING |
| ARMY - FSP | | THIRD ANGLE PROJECTION |
| DRAWN BY | B.T. | DATE |
| CHECKED BY | R.Z. | 11/3/11 |
| RELEASED BY | | PART NO. |
| | UNITS INCHES | SCALE N/A |
| | | SIZE C |
| | | DWG LEVEL 100 |
| | | REV |
| | | SHEET 1 OF 1 |

IP60
DWG

UNCLASSIFIED

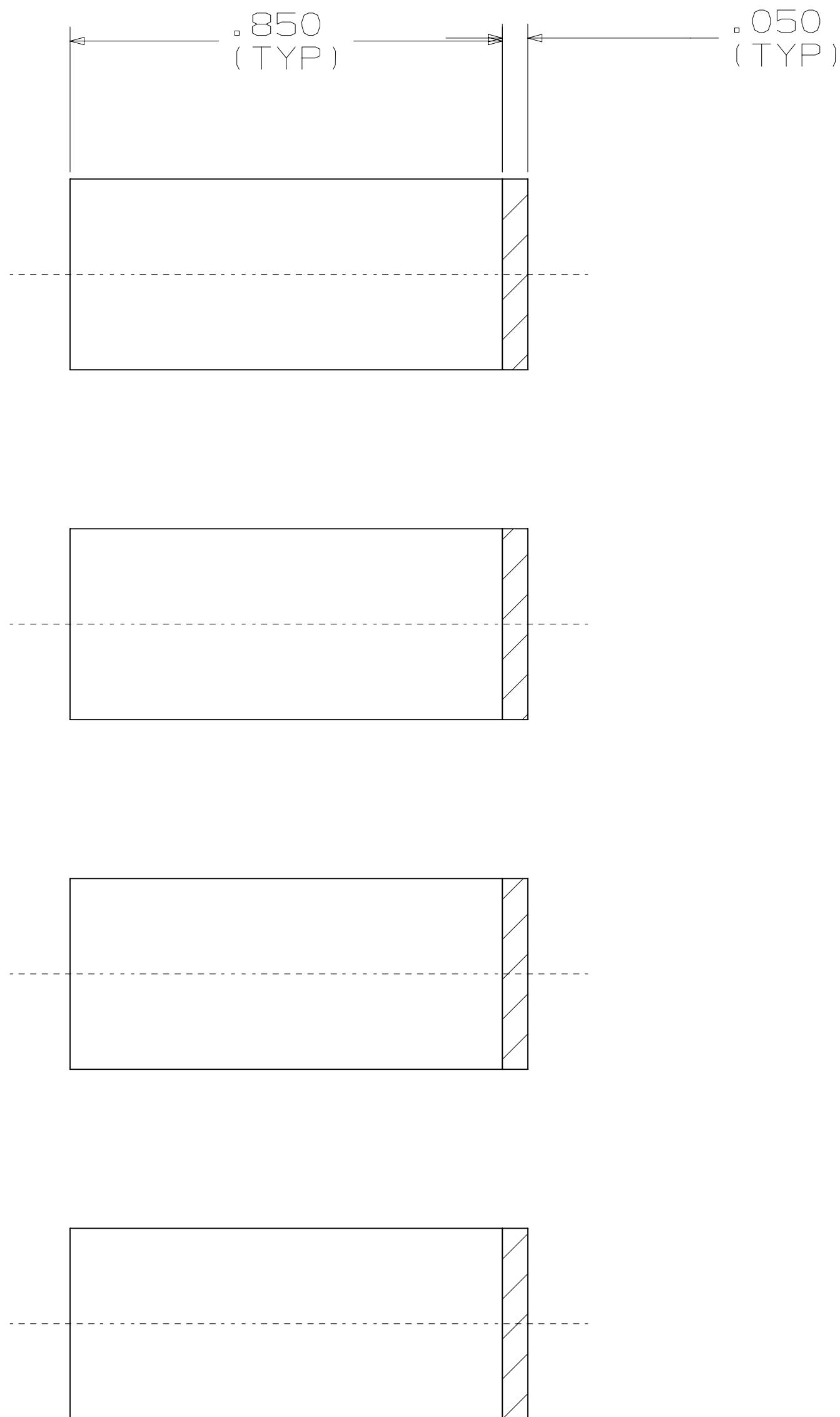
4

3

2

1

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
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| TOLERANCES | | ANGULAR | |
|---|-------|--|------------------|
| DECIMALS | | | |
| 1 PLACE | | ± .030 | ± 0° 30' |
| 2 PLACE | | ± .010 | FRACTIONS |
| 3 PLACE | | ± .005 | ± 1/64 |
| 4 PLACE | | ± .0005 | |
| UNLESS OTHERWISE SPECIFIED | | | |
| BREAK ALL SHARP EDGES | | | |
| MATERIAL : | | | |
| <input checked="" type="checkbox"/> CHANGE RESTRICTED | | <input checked="" type="checkbox"/> DO NOT SCALE | |
| USAGE : ARMY-FSP | | FOCUS: HOPE MANUFACTURING | |
| DRAWN BY B.T. DATE 11/3/11 | | DWG NO. SHPBC_IP70_DWG | |
| CHECKED BY R.Z. DATE 11/3/11 | | PART NO. X | |
| RELEASED BY UNITS INCHES | | SCALE N/A | SIZE C |
| | | DWG LEVEL 100 | REV SHEET 1 OF 1 |

4

3

2

1

UNCLASSIFIED

UNCLASSIFIED

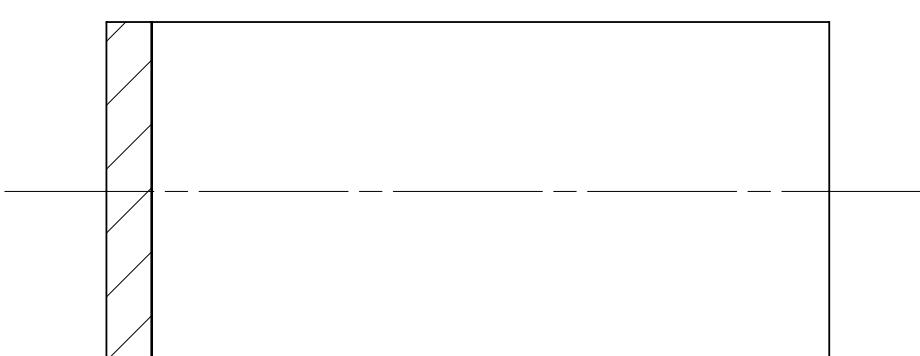
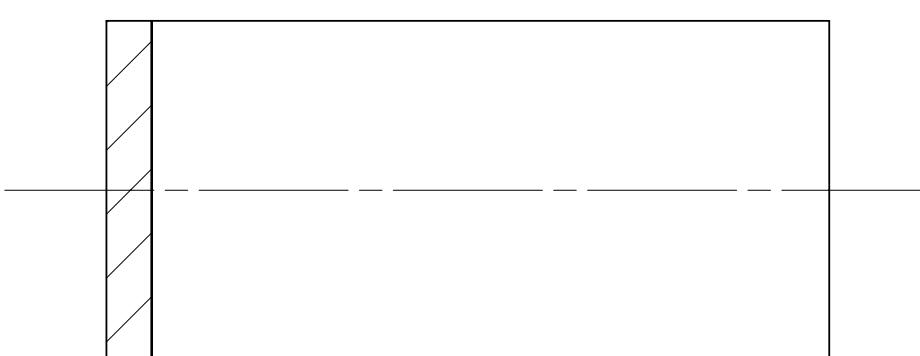
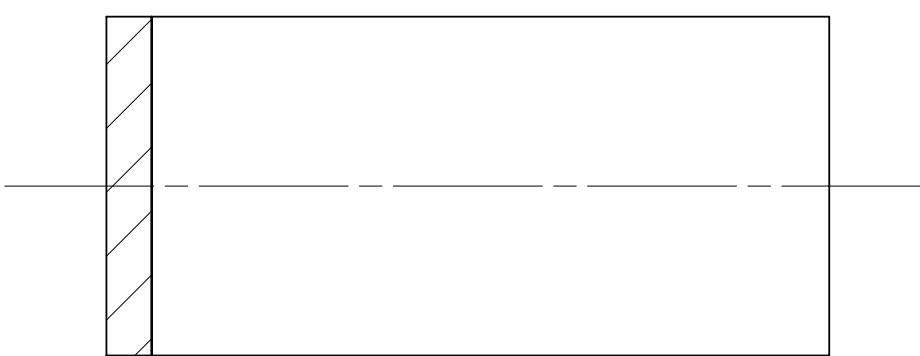
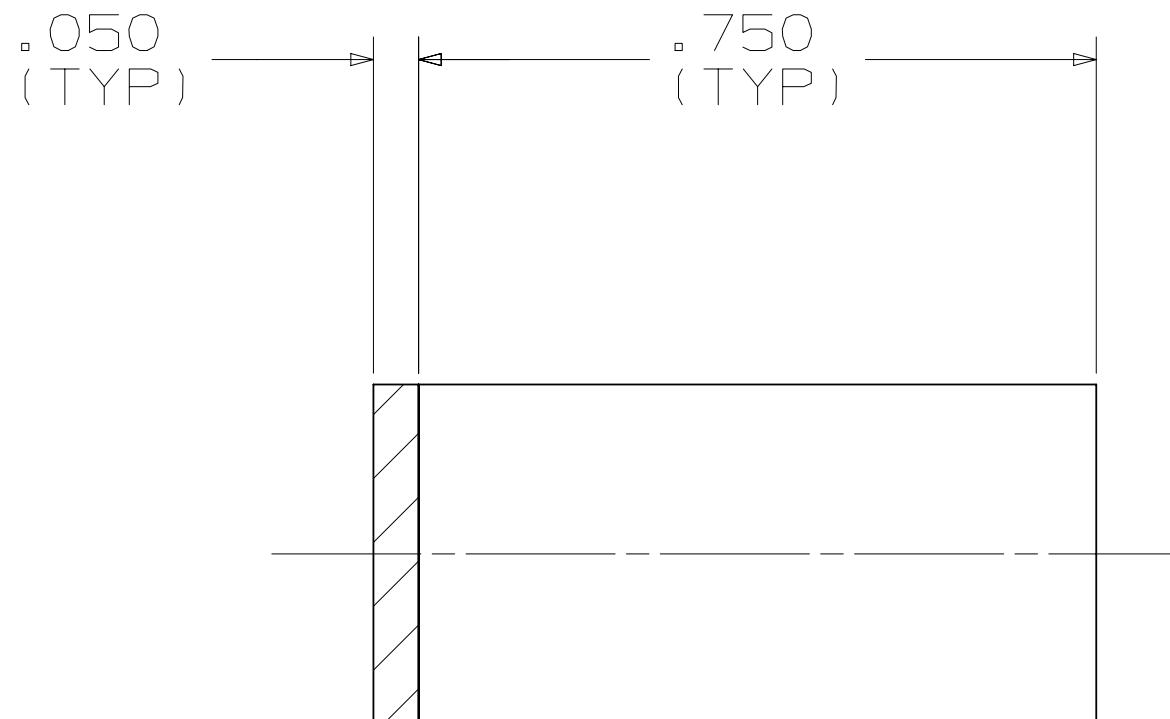
4

3

2

1

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
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TOLERANCES
DECIMALS

- 1 PLACE ± .030
2 PLACE ± .010
3 PLACE ± .005
4 PLACE ± .0005

ANGULAR

± 0° 30'

FRACTIONS
± 1/64

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

IP80
DWG

MATERIAL:

| CHANGE RESTRICTED | | DO NOT SCALE | | FOCUS: HOPE MANUFACTURING | |
|--------------------|------|------------------------|---------|---------------------------|----------------|
| USAGE: ARMY-FSP | | THIRD ANGLE PROJECTION | | PART NAME: SHPBC | |
| DRAWN BY | B.T. | DATE | 11/3/11 | DWG NO. | SHPBC_IP80_DWG |
| CHECKED BY | R.Z. | DATE | 11/3/11 | PART NO. | X |
| RELEASED BY | | UNITS | INCHES | SCALE | N/A |
| | | SIZE | C | DWG LEVEL | 100 |
| | | REV | | SHEET | 1 OF 1 |

4

3

2

1

UNCLASSIFIED

UNCLASSIFIED

Focus: HOPE Process routing/Shop traveler**Customer: Southwest Research Institute**

Street Address:

City State Zip:

Stock: **3/4 x 3/4 x 4 1/2 coupon (8)**Part Number: **SHPB Tensile (5083/6061)**Description: **Johnson-Cook test specimen**

Revision:

| Op No | Labor Code | Operation Description |
|-------|--------------|---|
| | | See 'Strips' Process Sheet for initial specimen extraction operations. |
| | | Extreme care must be taken to keep Specimen Types R, W, and A, and Materials 6061 and 5083 properly segregated. THIS IS EXTREMELY IMPORTANT, |
| 10 | | Confirm that all material blocks are marked "6061-W" |
| 20 | Mill | Square mill end, round (circular interpolate) end to 0.70 dia x 0.88 and center drill |
| 30 | Laser | Mark end "61W-#" (where # = 1 thru 8) |
| 40 | Mill | Mill end square, center drill, rough contour turn, final contour turn, single point thread, and finally turn thread OD to .490 dia |
| 50 | laser marker | Mark 2 Places (ends) "61W-#" (where # = 1 thru 8) |
| 60 | | Individually bag each part |
| 70 | | Label Bags |
| 80 | | Polish Longitudinally |
| 90 | | Cut-off to final length 2.235 |
| | | |

UNCLASSIFIED

UNCLASSIFIED

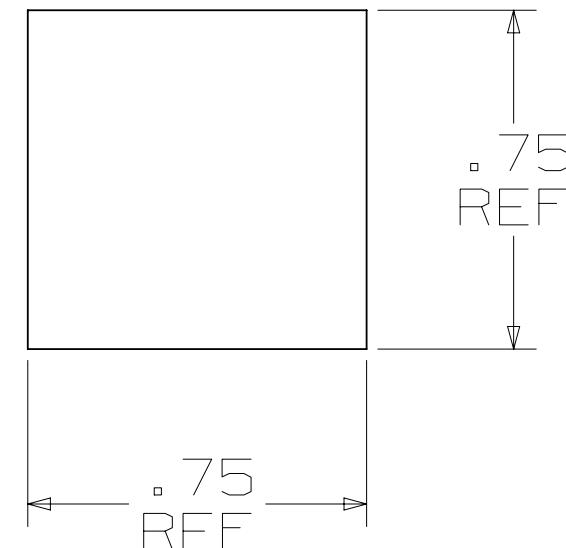
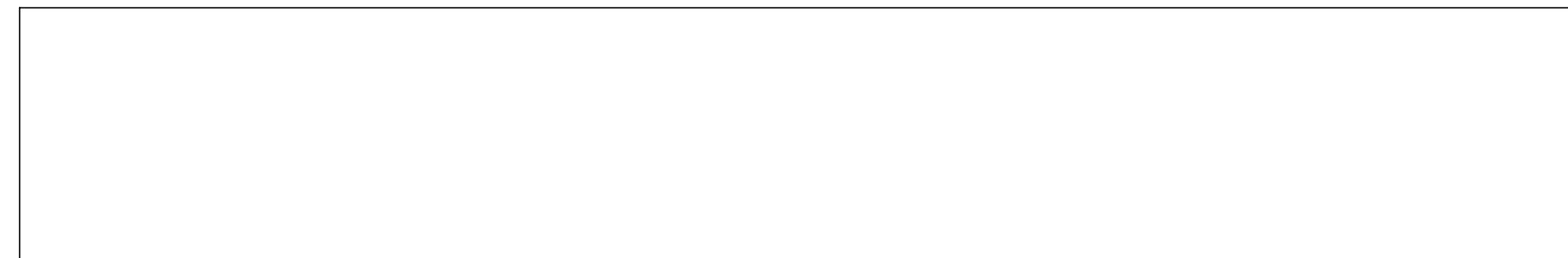
4

3

2

1

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
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TOLERANCES

DECIMALS

| | |
|---------------|-------------|
| 1 PLACE | $\pm .030$ |
| 2 PLACE | $\pm .010$ |
| 3 PLACE | $\pm .003$ |
| 4 PLACE | $\pm .0005$ |

| | |
|-----------|-------------------|
| ANGULAR | $\pm 0^\circ 30'$ |
| FRACTIONS | $\pm 1/64$ |

UNLESS OTHERWISE SPECIFIED

MATERIAL:

| | | |
|-----------------|-------------------|---|
| UG | CHANGE RESTRICTED | D<small>O</small> NOT S<small>CALE</small> |
| USAGE: | | FOCUS: HOPE MANUFACTURING |
| ARMY-FSP | | THIRD ANGLE PROJECTION |
| DRAWN BY B.T. | DATE 10/6/11 | DWG NO. SHPB_TENSILE_IP10_DWG |
| CHECKED BY R.Z. | 10/6/11 | PART NO. |
| RELEASED BY | | SCALE N/A |
| | | SIZE C |
| | | DWG LEVEL 100 |
| | | REV |
| | | SHEET 1 OF 1 |

4

3

2

1

UNCLASSIFIED

UNCLASSIFIED

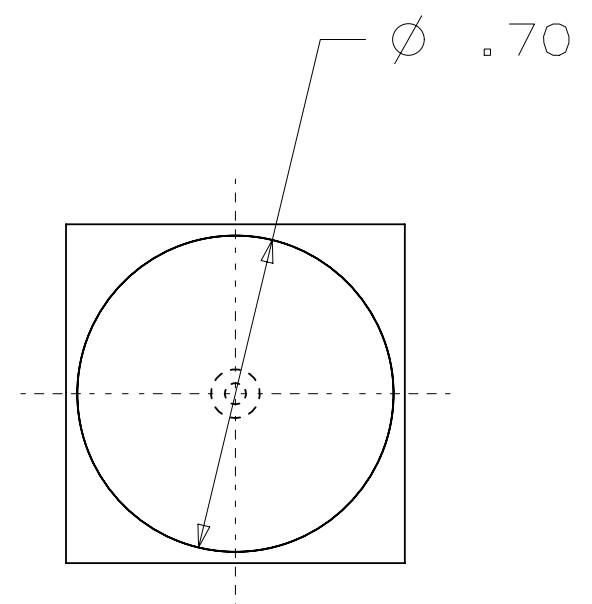
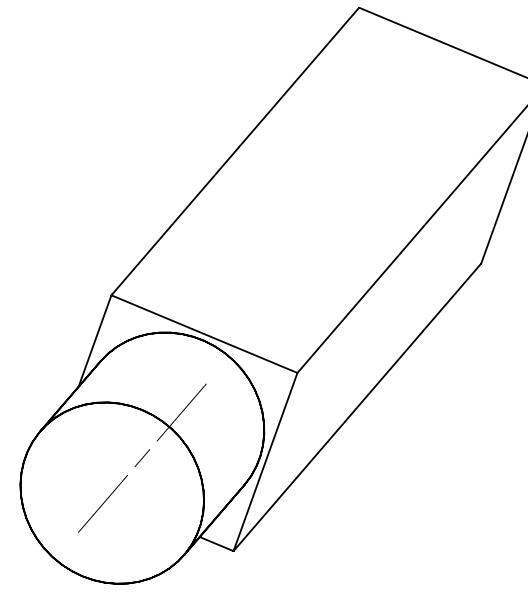
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3

2

1

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
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TOLERANCES

DECIMALS

- 1 PLACE $\pm .030$
 2 PLACE $\pm .010$
 3 PLACE $\pm .003$
 4 PLACE $\pm .0005$

ANGULAR

 $\pm 0^\circ 30'$

FRACTIONS

 $\pm 1/64$

UNLESS OTHERWISE SPECIFIED

MATERIAL:

IP20
DWG

| | | |
|-----------------|-------------------|-------------------------------|
| | CHANGE RESTRICTED | |
| USAGE: | ARMY FSP | FOCUS: HOPE MANUFACTURING |
| DRAWN BY B.T. | DATE 10/6/11 | PART NAME SHPB TENSILE |
| CHECKED BY R.Z. | 10/6/11 | DWG NO. SHPB_TENSILE_IP20_DWG |
| RELEASED BY | SCALE N/A | SIZE C |
| | | DWG LEVEL 100 |
| | | REV |
| | | SHEET 1 OF 1 |

4

3

2

1

UNCLASSIFIED

UNCLASSIFIED

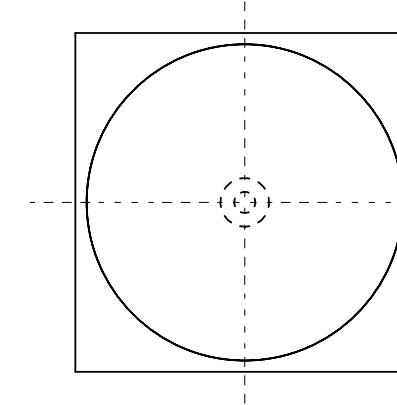
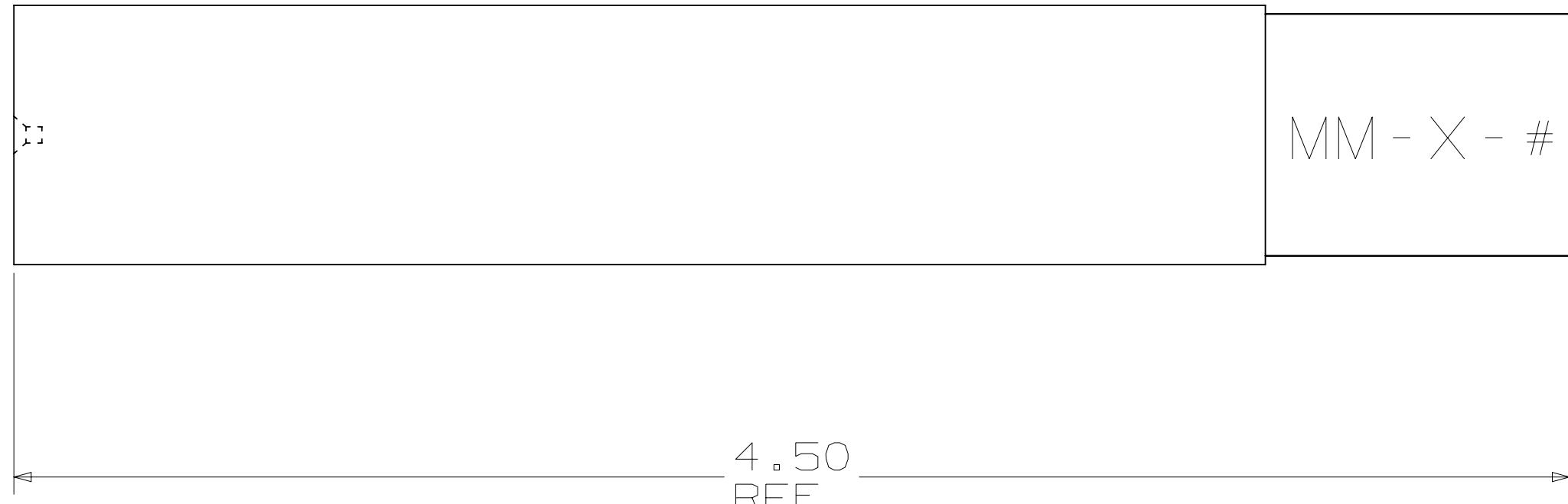
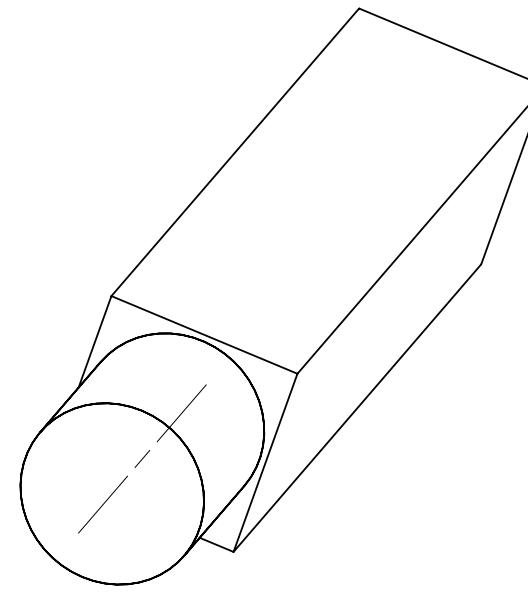
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3

2

1

| DATE | ZONE | STG | P&G | REV | DESCRIPTION | CN# | CHG | APV |
|------|------|-----|-----|-----|-------------|-----|-----|-----|
| | | | | | | | | |
| | | | | | | | | |
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MM - X - #

4.50
REF

TOLERANCES

DECIMALS

- 1 PLACE ± .030
 2 PLACE ± .010
 3 PLACE ± .003
 4 PLACE ± .0005

ANGULAR

± 0° 30'

FRACTIONS

± 1/64

UNLESS OTHERWISE SPECIFIED

MATERIAL:

IP30
DWG

| | | | |
|-------------|-------------------|------------------|----------------------------------|
| WG | CHANGE RESTRICTED | D&O | NOT SCALE |
| USAGE: | ARMY FSP | FOCUS: | HOPE MANUFACTURING |
| DRAWN BY | B.T. | DATE | DWG NO. SHPB_TENSILE_IP30_DWG |
| CHECKED BY | R.Z. | 10/6/11 | PART NO. |
| RELEASED BY | | SCALE N/A | SIZE C |
| | | DWG LEVEL 100 | REV 1 |
| | | | SHEET 1 OF 1 |

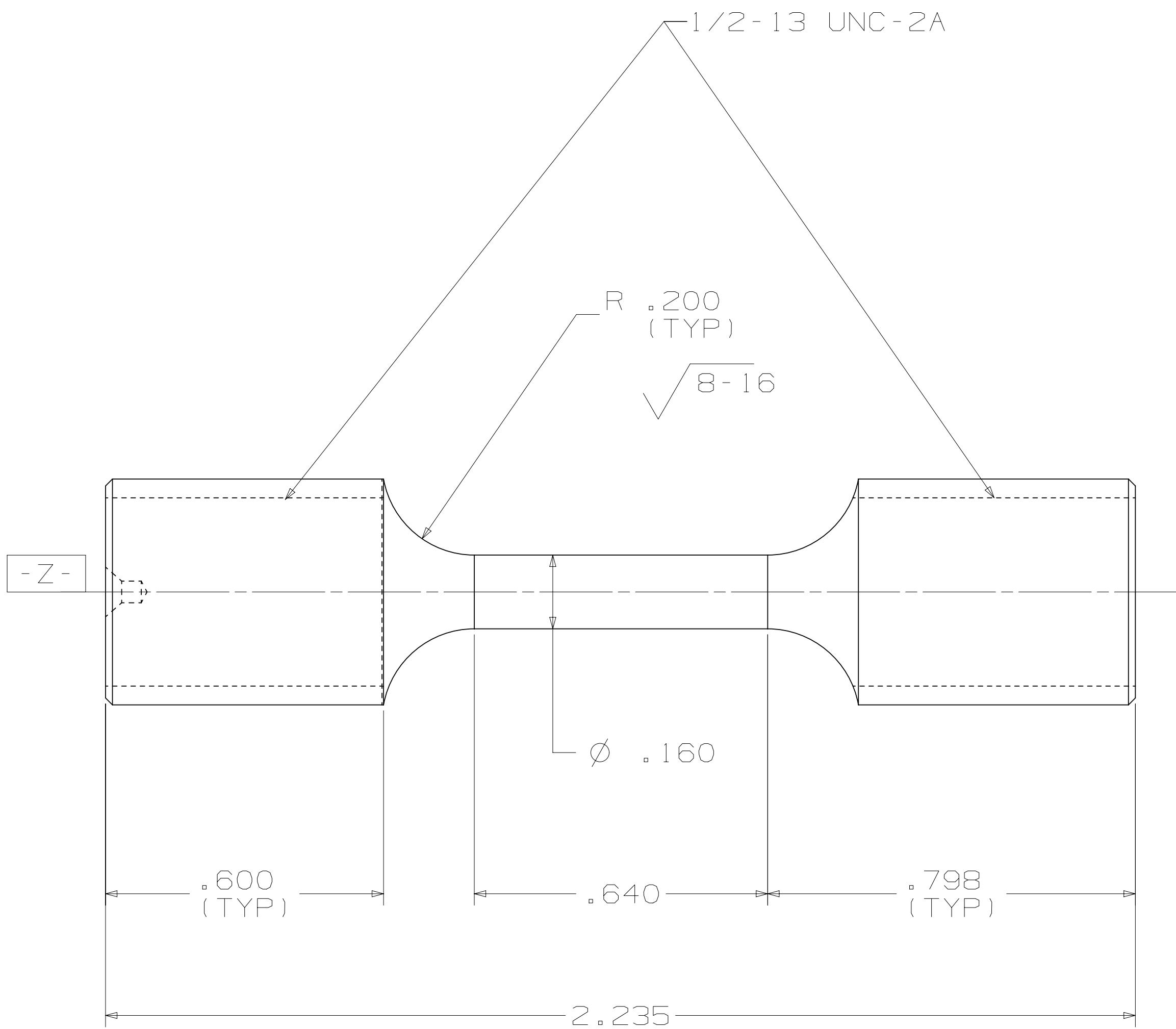
4

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2

1

UNCLASSIFIED



TOLERANCES (INCH)
DECIMALS

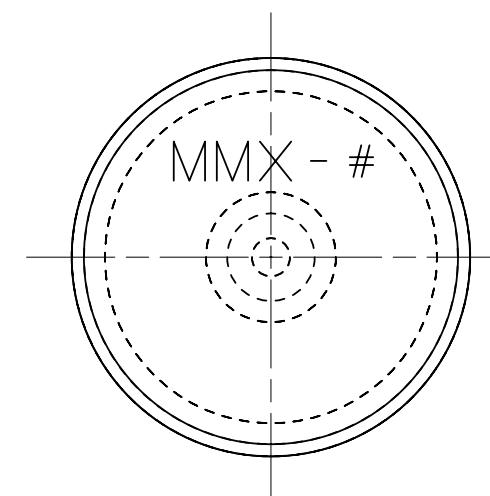
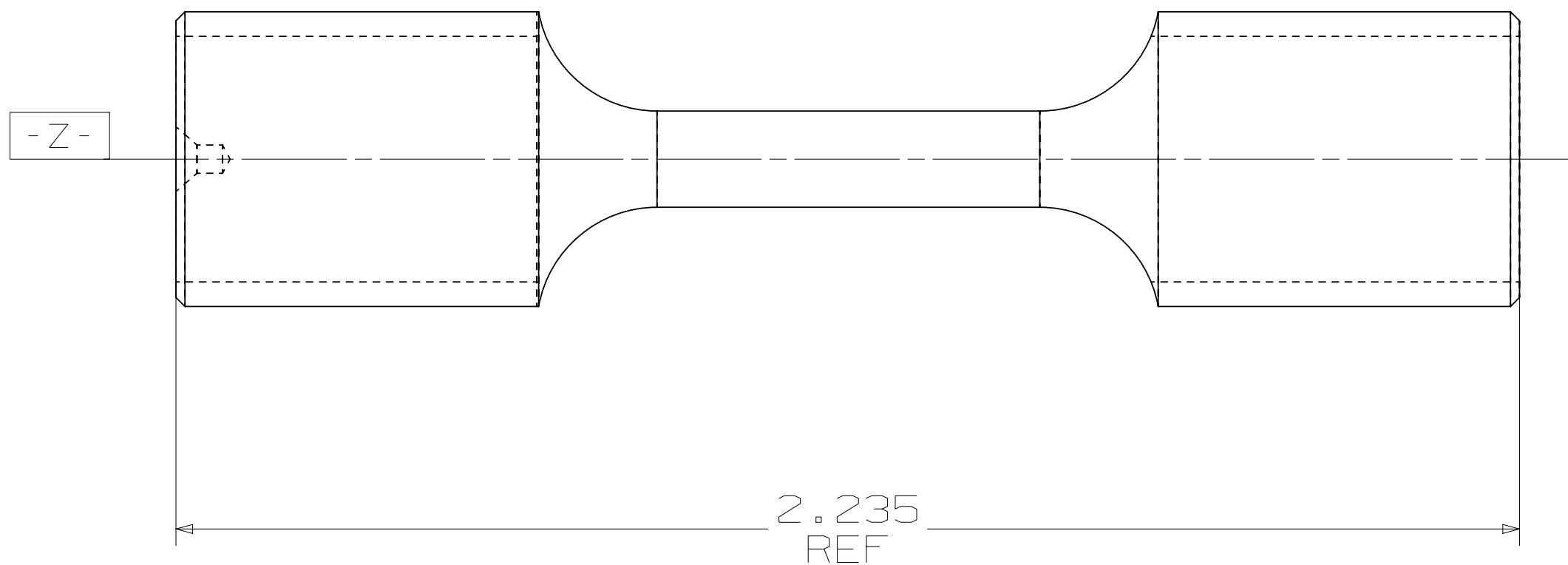
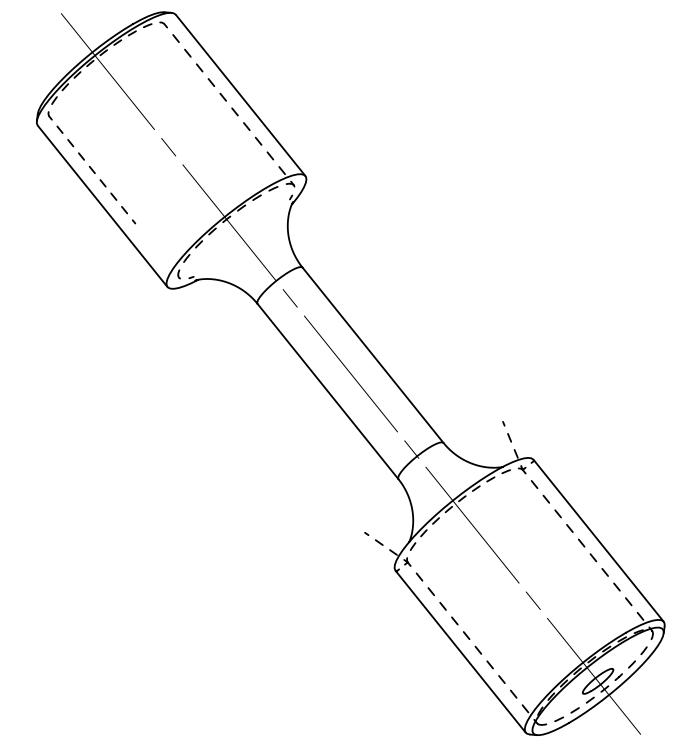
1 PLACE..... $\pm .030$
2 PLACE..... $\pm .010$
3 PLACE..... $\pm .005$
4 PLACE..... $\pm .0005$

UNLESS OTHERWISE SPECIFIED

MATERIAL:

ANGULAR
 $\pm 0^\circ 30'$
FRACTIONS
 $\pm 1/64$

| UG CHANGE RESTRICTED | | DO NOT SCALE | |
|----------------------|---------|------------------------------|-----------|
| USAGE: ARMY FSP | | FOCUS: HOPE MANUFACTURING | |
| DRAWN BY B.T. | | DATE 10/7/11 | |
| CHECKED BY R.Z. | 10/7/11 | PART NO. | |
| RELEASED BY | | SCALE N/A | SIZE C |
| | | DWG LEVEL 100 | REV 1 |
| | | SHEET 1 OF 1 | |



TOLERANCES (INCH)
DECIMALS

1 PLACE..... ± .030
2 PLACE..... ± .010
3 PLACE..... ± .005
4 PLACE..... ± .0005

UNLESS OTHERWISE SPECIFIED

MATERIAL:

ANGULAR
± 0° 30'

FRACTIONS
± 1/64

| CHANGE RESTRICTED | | DO NOT SCALE | |
|--------------------|--|------------------------------|---------------------|
| USAGE: | | FOCUS: HOPE MANUFACTURING | |
| DRAWN BY B.T. | | DATE 10/7/11 | |
| CHECKED BY R.Z. | | PART NO. | |
| RELEASED BY | | SCALE N/A | SIZE C |
| | | | DWG LEVEL 100 |
| | | | REV SHEET 1 OF 1 |

IP50
DWG